hp 202A

HEWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

202A

LOW FREQUENCY FUNCTION GENERATOR

00011-

hp 202A

CERTIFICATION

THE HEWLETT-PACKARD COMPANY CERTIFIES THAT THIS INSTRUMENT WAS THOROUGHLY TESTED AND INSPECTED AND FOUND TO MEET ITS PUBLISHED SPECIFICATIONS WHEN IT WAS SHIPPED FROM THE FACTORY.

hp FURTHER CERTIFIES THAT ITS CALIBRATION MEASUREMENTS ARE TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS TO THE EXTENT ALLOWED BY THE BUREAU'S CALIBRATION FACILITY.

OPERATING AND SERVICE MANUAL

MODEL 202A

SERIALS PREFIXED: 325-

LOW FREQUENCY FUNCTION GENERATOR

00011-4

Printed: AUG 1963

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

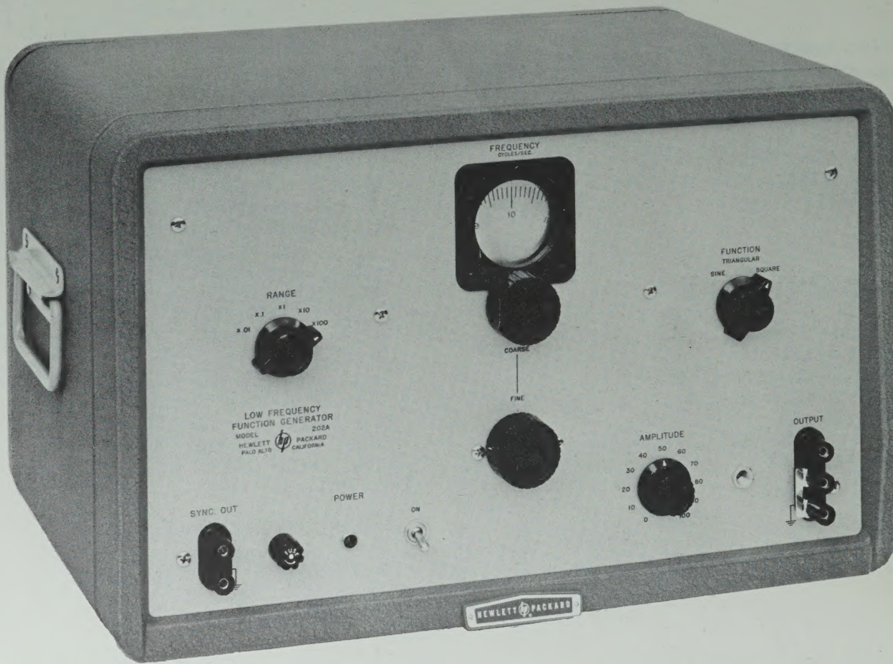


Figure 1-1. Model 202A. Low Frequency Function Generator

Table 1-1. Specifications

FREQUENCY RANGE:
0.008 to 1200 cps in five decade ranges with wide overlap at each dial extreme

DIAL ACCURACY:
Within ±2% from "1.2" to "12" on dial; ±3% from ".8" to "1.2"

FREQUENCY STABILITY:
Within ±1% including warm-up drift and line voltage variations of ±10%

OUTPUT WAVEFORMS:
Sinusoidal, square, and triangular. Selected by panel switch

MAXIMUM OUTPUT VOLTAGE:
At least 30 volts peak-to-peak across rated load (4000 ohms) for all three waveforms. (10.6 volts rms for sine wave)

FREQUENCY RESPONSE:
Constant within ±0.2 db over entire frequency range at rated output and load

INTERNAL IMPEDANCE:
Approximately 40 ohms over the entire range

SINE WAVE DISTORTION:
Less than 1% on all ranges except X100. Less than 2% rms on X100.

SECTION I
GENERAL INFORMATION

1-1. GENERAL.

The Model 202A Low Frequency Function Generator is a compact, convenient, and versatile source of transient-free test voltages between .008 and 1200 cycles per second. It is useful for any general purpose low frequency testing application and is particularly valuable in the testing of servo systems, geophysical equipment, vibration and stability characteristics of mechanical systems, electro-medical equipment, and for the electrical simulation of mechanical phenomena. Three types of output waveform are available; sine, square and triangular. Also, a sync output pulse is available for external use.

The Model 202A Low Frequency Function Generator contains a type of relaxation oscillator that is particularly advantageous for the generation of very low frequencies. Both a triangular and a squarewave voltage function of time are inherent in the oscillating system. Also, a sinewave function is produced by synthesis from the triangular wave.

Output amplitude and distortion are virtually independent of the frequency of operation. This type of oscillating system is inherently a constant amplitude device so that no A.V.C. system, with associated delay in stabilization after frequency changes, is required.

The frequency range from .008 to 1200 cycles per second is covered in 5 bands. The frequency dial is linear.

The output system is a direct-coupled amplifier system designed for either single ended or balanced output. It has good stability with respect to direct current in the output and very low hum level. Both the FUNCTION selectro switch and the AMPLITUDE control are so arranged that the characteristics of the amplifier are independent of their position. The internal impedance of the output amplifier is approximately 40 ohms, and the unit is rated to deliver at least 30 volts peak-to-peak to a 4000 ohm load.

A negative peak sync pulse of 10 volts into a 2500 ohm load is also provided. It has a duration of less than 5 microseconds and occurs at the crest of the sinewave and at corresponding positions with the other functions.

Table 1-1. Specifications (Cont'd)

OUTPUT SYSTEM:
Can be operated either balanced or single-ended. Output system is direct-coupled; dc level of output voltage remains stable over long periods of time.

HUM LEVEL:
Less than 0.05% of maximum output.

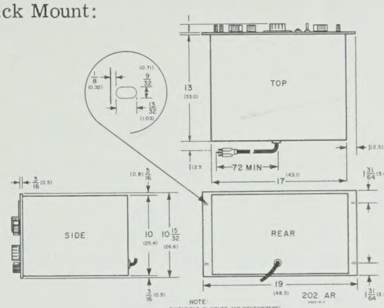
SYNC PULSE
10 volts peak negative, less than 5 microseconds duration. Sync pulse occurs at crest of sine wave and with corresponding positions on other waveforms.

WEIGHT:
Cabinet Mount: Net 42 lbs
Rack Mount: Net 37 lbs

POWER:
115 or 230 volts ±10%, 50 to 1000 cps, 150 watt

DIMENSIONS: Cabinet Mount: 20-3/4 in. wide, 12-3/4 in. high, 14-5/8 in. deep.

Rack Mount:



SECTION II
OPERATING INSTRUCTIONS

2-1 INSPECTION

After the instrument is unpacked, the instrument should be carefully inspected for damage received in transit. If any shipping damage is found, follow the procedure outlined in the "Claim for Damage in Shipment" page at the back of the instruction book.

2-2 CONTROLS AND TERMINALS

RANGE
This switch is used to select the desired frequency range to be covered by the frequency dial.

FUNCTION
This switch is used to select any one of the three types of output waveform.

FREQUENCY
This dial is calibrated directly in cycles per second for the X1 frequency range of the oscillator. The knob just below the dial escutcheon is directly connected to the frequency varying element. The lower knob is a mechanical vernier for fine adjustment of the frequency.

AMPLITUDE
This control adjusts the amplitude of the oscillator voltage admitted to the amplifier and, therefore, the output of the instrument. This control is calibrated from 0 to 100 in arbitrary units.

POWER
This toggle switch controls the power supplied to the instrument from the power line.

FUSE
The fuseholder, which is located on the panel, contains the power line fuse. Refer to the Table of Replaceable Parts for the correct fuse rating.

OUTPUT
This group consists of three terminals. The one marked "G" is connected directly to the instrument chassis. The other two terminals, vertically aligned, are the OUTPUT terminals. With respect to the ground terminal each of these outputs has equal magnitude of signal, but they are 180° out of phase with each other. The internal impedance between the two OUTPUT terminals is approximately 40 ohms.

SYNC OUT
The Sync Out terminals are single-ended and have an internal impedance of about 2,000 ohms.

Power Cable
The three-conductor power cable is supplied with a three-prong plug. The third prong is a round off-set pin which provides a chassis ground. An adapter may be obtained to permit use of this plug with two-conductor receptacles.

2-3 230-VOLT OPERATION

This instrument is shipped from the factory with the power transformer primaries connected in parallel for 115 v operation, unless otherwise specified on the order. If 230 v operation is desired, the primaries will have to be connected in series as shown in "Transformer Details" on the schematic wiring diagram of the Power Supply Section.

2-4 OPERATION

The following step-by-step procedure should be used as a guide when operating this instrument.

1) Turn the POWER switch to ON. Allow thirty seconds for oscillations to start. The instrument will operate nearly within specifications after a few minutes warm-up. It will be within specifications after 30 minutes.

2) Set the RANGE and FREQUENCY controls for the desired frequency. The frequency dial scale must be multiplied by the multiplying factor indicated by the RANGE switch setting to obtain the oscillator frequency. Example: 4 (on dial scale) x .1 (multiplying factor indicated by RANGE switch setting) = .4 cycles/sec.

3) Set the FUNCTION switch for the desired output waveform.

4) Connect the equipment under test to the OUTPUT terminals.

5) Adjust the AMPLITUDE Control for the desired output voltage. Because the frequency response is rated ±0.2 db, the output amplitude may be measured at any convenient frequency and the output level will be correct (within these limits) for any other frequency.

NOTES

When small output voltages are required it may be desirable to use an external attenuator. This is because the hum and noise in the output is nearly constant with output amplitude.

To minimize distortion in the output waveform, always use the lowest RANGE when the overlap of the FREQUENCY dial permits a choice.

2-5 SINGLE-ENDED OUTPUT

The terminal marked "G" is isolated from the actual OUTPUT terminals. For single-ended operation "G" must be connected to one of the OUTPUT terminals, and the strapped pair will then be the ground side of the output.

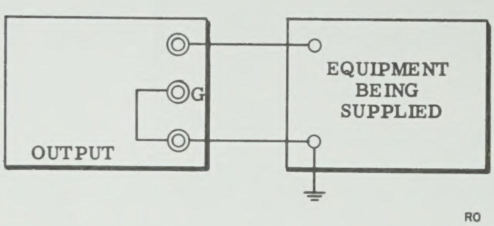


Figure 2-1. Single-Ended Output Connections

2-6 BALANCED OUTPUT

Connect the two OUTPUT binding posts to the equipment being supplied. The "G" binding post may then be connected to the chassis of the equipment being driven. Under these conditions the internal impedance of the Model 202A from either OUTPUT terminal to ground is 7900 ohms in series with a 1 μf capacitor (C29). A maximum dc voltage of 400 volts may be applied between either OUTPUT terminal and the "G" terminal without damaging the 1 μf capacitor (C29). The 40 ohms internal impedance (resistive) will shunt the impedance existing between the two signal inputs of the system being driven. Under circumstances where the connection places the Model 202A in series with a path carrying current, distortion of the Model 202A output will occur if greater than 10 ma peak current is caused to flow through the Model 202A output system.

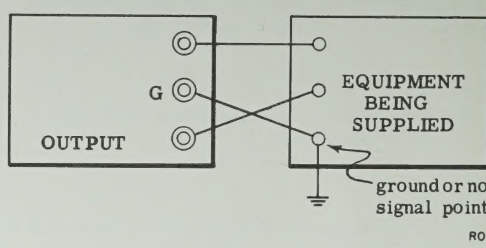


Figure 2-2. Balanced Output Connections

2-7 SYNC. OUT

The SYNC. OUT is a negative pulse of less than 5 microseconds duration and at least 10 volts peak amplitude. It occurs on one of the sine and triangular crests and at the rise or fall of the squarewave. It occurs at the positive crests with respect to one of the OUTPUT terminals and at the negative crest of the other. Therefore, it can be changed by 180° with respect to the output system by reversing connections to the two OUTPUT terminals which are otherwise completely interchangeable. The SYNC. OUT terminal marked "G" is directly connected to the chassis.

SECTION III
PRINCIPLES OF OPERATION

3-1 GENERAL

Figure 3-1 depicts the general scheme of the ⓗⓟModel 202A and indicates the waveforms produced. The bi-stable circuit consists of a flip-flop circuit capable of producing a square-wave output at point A, provided it is triggered at the proper time. This is done by including in the bi-stable circuit, a two-way comparator circuit which produces the proper triggers for the flip-flop whenever the switching signal becomes equal to either the "plus switching reference" or the "minus switching reference". The triangular switching signal returned to the bi-stable circuit is that seen between points B and D. The conversion of square wave to triangular wave takes place in the integrator unit which is carefully designed to produce an accurate integral of the applied square wave. The bi-stable circuit and linear integrator are loop coupled in such a manner that the resulting relaxation oscillator is suitable for very low frequency operation.

The sinewave output is taken from a point C between the triangular voltage at point B and the average level at point D. The resistance between B and C is fixed, and the network between C and D is a

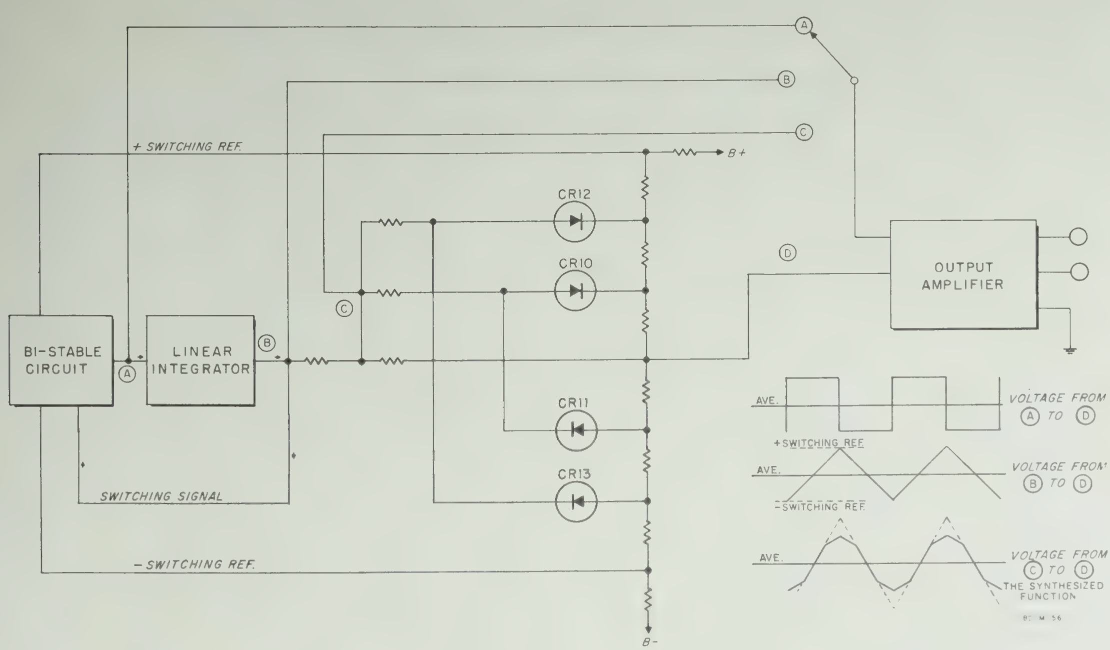


Figure 3-1. Model 202A Function Generator

non-linear system which synthesizes a sinewave from the triangular wave. This network consists of a group of biased diodes arranged in such a manner that at certain predetermined voltage levels they begin to conduct, therefore, providing shunt paths from C to D. Each additional shunt path reduces the slope of the triangle in the proper amount so that the wave is shaped to approximate a sinewave.

This approximation is as shown, and the degree to which a sinewave may be approached depends on the number of diodes. Thus there are available the sinewave C, triangular wave B, and square-wave A functions with respect to D to be selected and brought to the OUTPUT terminals through the output amplifier. The output amplifier has a differential input and push-pull output.

3-2 BI-STABLE CIRCUIT

Figure 3-2 shows the details of the bi-stable circuit and includes the integrator in block form in order to indicate the bilateral connection from integrator output to comparator input.

The portion of the diagram composed of V1, V2 and V3 is the "bi-stable circuit". Actually, this circuit is a combination of two circuits. If capacitors C10 and C13 are disconnected so that there is no possibility of inductive coupling from grids to cathode of V1 and V2, the remaining circuit is the well-known "flip-flop" or Eccles-Jordan trigger circuit. The other circuit which appears in the bi-stable circuit is a voltage comparator known as the "Multiar". The multiar is a circuit which employs a regenerative loop to produce a pulse when the two input voltages are equal. There are two of these in the bi-stable unit. One multiar is composed of V1, V3A and T2, and the other of V2, 3B and T1.

The cathode of V3A and the plate of V3B are connected to reference voltages derived from the voltage regulator tubes V5 and V6. The triangular wave is applied to the plate of V3A and the cathode of V3B. As the voltage on the plate of V3A rises towards the plus switching reference, V1 is conducting, but when V3A conducts, a negative pulse is formed on the grid of V1 which flips the Bi-Stable Unit to its other stable state and starts the voltage on the cathode of V3B towards the minus switching

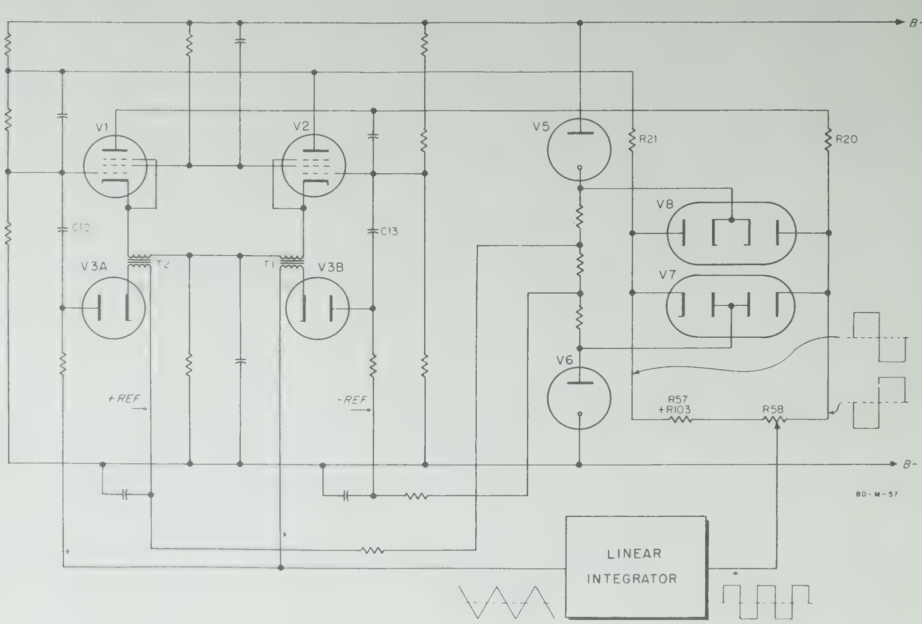


Figure 3-2. Details of Bi-Stable Circuit and Switching System

reference. When V3B conducts the Bi-Stable Unit is flipped back to its original state, completing one cycle of operation.

Voltage regulator tubes V5 and V6 are connected by a voltage divider from which the switching reference voltages are taken. They also provide the limiting voltages applied to tubes V7 and V8 which are seen to be a push-pull clamping system. Inasmuch as the integrator output is directly related to the input, it is seen that the magnitude of squarewave applied must be carefully controlled. Although only the squarewave appearing at the plate of V1 is needed to drive the integrator, the clamp is made push-pull to prevent excessive current variations in the regulator tubes. The action of V7B and V8B is such that if the applied waveform has peak excursions in excess of the potentials on the remaining cathode and plate, these being determined by regulator tubes V5 and V6, a current will flow through R20 which drops the voltage to very nearly the potential of the regulated element of the conducting section of the diode. The action of the other diodes is the same, but 180° out of phase, inasmuch as they are coupled to the plate of V2. In this way, waveforms appearing on the clamped sides of R21 and R20 are assured to be of equal magnitude as well as 180° out of phase, and further the average of dc level of the squarewave is accurately controlled.

3-3 LINEAR INTEGRATOR

Consider the block diagram of the linear of feedback integrator as shown in Figure 3-3. Starting with the output voltage E_o, it is seen that if the gain of the amplifier is high, then the signal appearing at the junction of R and C (the amplifier input) must be small. For a fixed output E_o as the gain is increased the resultant signal at the input of the amplifier becomes arbitrarily small. Since the voltage at the junction at R and C is arbitrarily small, a squarewave applied to the input will cause a constant current in R. Because the current charging and discharging C is constant, except for direction, the voltage across C will be triangular. Since there is virtually no signal at the junction of R and C the output voltage must also be triangular.

In this case the frequency of the applied signal is so low that the amplifier used must be direct coupled. There is a net voltage rise between input level and output level in a dc amplifier. In this particular application the average output level is determined as the average of the "plus reference" and "minus reference" levels, since the output excursion is limited to these levels. If this level does not coincide with the average level of the applied squarewave, then the positive and negative excursions of the squarewave will not be equal, resulting in unequal rise and fall rates of the output triangle. Because the squarewave input is generated from the triangular output by the bi-stable circuit, the net result is that under such conditions the squarewave is really a rectangular wave. The resulting rectangular wave has an average value just equal to that demanded of the amplifier input by virtue of the pre-set output level. The average levels of the input and output are stabilized by the use of a differential amplifier that has high gain to the difference between the voltage applied to its inputs but little or no gain to any voltage change common to both inputs.

Figure 3-4 shows how this is done. The right hand grid of the differential amplifier V15, is the signal input and is driven through R by the rectangular wave appearing on the FREQUENCY control. The average voltage of this rectangular wave is dependent on the clamping levels and the ratio of "on" to "off" time. When the system is adjusted for equal on-off times (squarewave) the average is just the average of the clamping levels. The left hand grid has no signal because the voltage divider which includes the balance control is connected to the no-signal sides of the clamping tubes. However, any change in the clamping level changes the average level appearing on both input grids in the same amount. Due to the large common cathode resistors of V15 and V16 a common mode change has very little effect. The input to the left hand grid has another function. If the balance control R60, is varied slightly, the output of the amplifier will show a considerable change in average level; and therefore

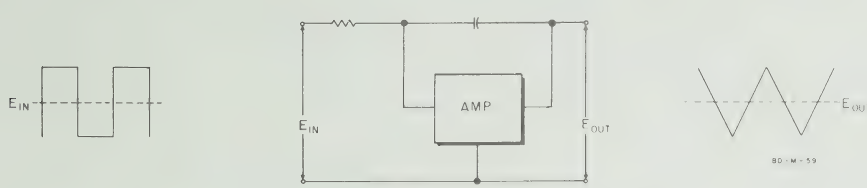


Figure 3-3. Generalized Miller or Feedback Integrator

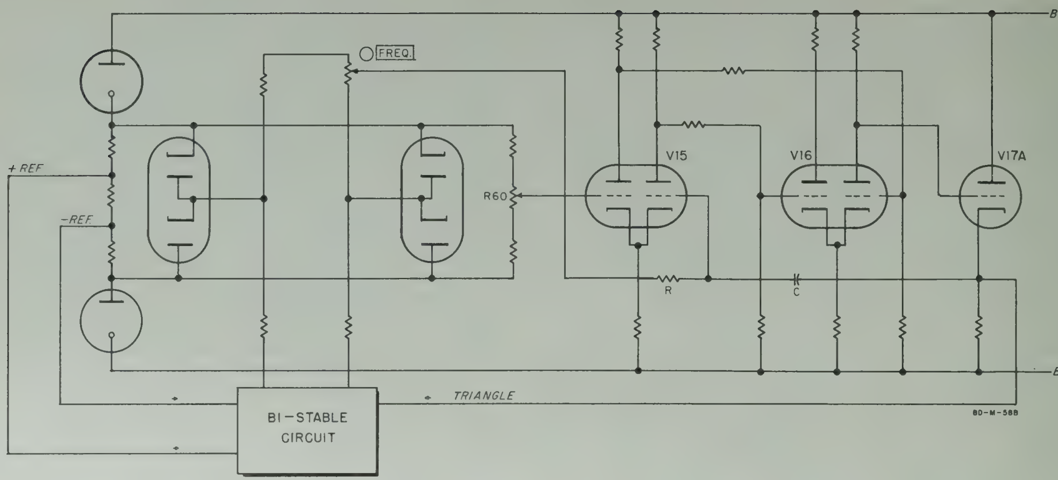


Figure 3-4. Simplified Linear Integrator

the average level of the output can be adjusted to exactly the voltage midway between the "reference" levels. This control then serves adequately to adjust the triangular wave balance which in turn equalizes the on-off time of the squarewave. The signals appearing at the plates of the first tube V15, are 180° out of phase and nearly equal in magnitude. These signals are also very nearly the difference between the inputs on the two grids. Since there is no signal on the left grid, the only signal into the amplifier is that at the junction of R and C, which is the condition originally required. The second stage is a push-pull amplifier employing the signals from the plates of the previous stage. Again the common cathode resistance is very high, but there is very little degeneration of the push-pull input. The gain of the system to changes common to both grids is about one-half while the gain to voltages appearing between the input grids is something over 250. Finally C is fed back to the signal grid from the cathode of V17A which is 180° out of phase with the signal input.

The cathode follower is used as an isolation stage between the integrator and the bi-stable circuit. This completes the oscillating loop with its inherent production of both square and triangular functions.

3-4 SINE SYNTHESIZER AND FUNCTION SELECTOR SWITCH

The triangular wave from the linear integrator is connected to R94. In the SINE position of the FUNCTION selector switch (S3) the other end of R94 is connected to the sine synthesizing diodes and to R93B, one half of the dual AMPLITUDE potentiometer. The synthesized sinewave signal appears as the difference signal between points C and D, but an error signal which appears at D with respect to B- also appears at C with respect to B-. This composite signal is applied to a differential amplifier in the output circuit.

The plus and minus switching references in the bi-stable unit are adjusted so that the ratio of the triangular wave amplitude to the conduction voltages of the synthesizer diodes produces the least distortion of the sinewave. This adjustment also fixes the average voltage at C and is equal to the average of the plus and minus switching references.

The dc voltages at D, and the cathode of V4 are adjusted to be the average of the plus and minus switching references. Since these voltages are equal there is no change in DC level applied to the Output Amplifier as the AMPLITUDE control is varied.

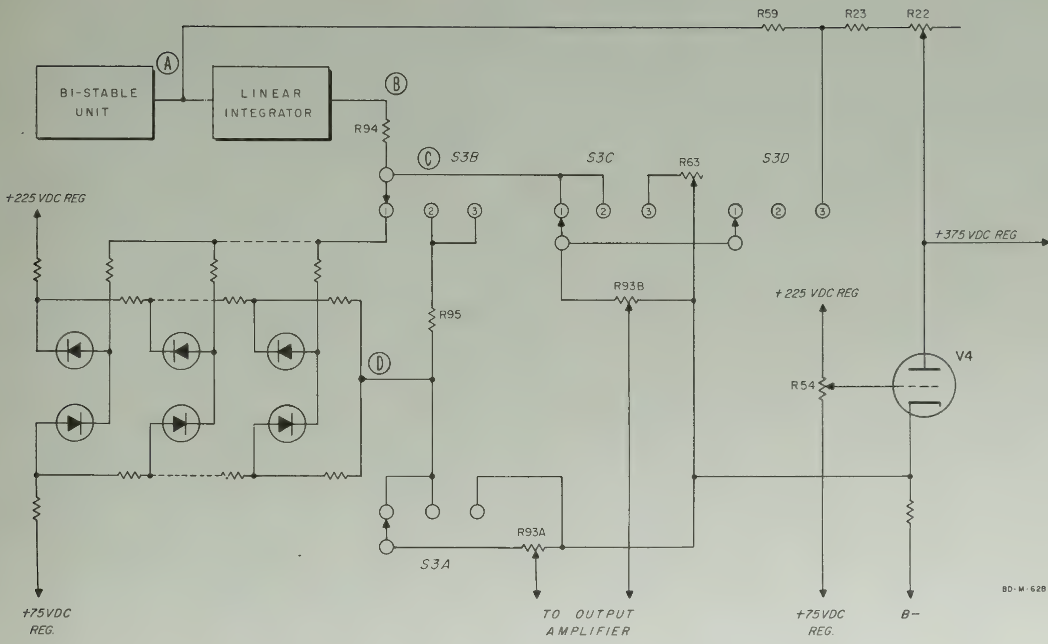


Figure 3-5. Sine Synthesizer and Function Selector

(A) Waveform from integrator output to B-. Triangular regardless of function selector position.

(B) Waveform from Ⓒ to B- with selector switch in sine position. Note distortion especially at peaks.

(C) Waveform from Ⓓ to B- with selector switch in sine position. This is the distortion component present in waveform (B) above.

(D) Waveform from Ⓒ to Ⓓ. (i. e.: difference between waveforms (B) and (C) above.) This is the approximated sinewave.

RO

Figure 3-6. 50 ∿ Waveforms

The sinewave is approximated by varying the shunt resistance across R93B is steps determined by the diode synthesizing network. The waveform slope, at first, is just that determined by R94, R93B and the input waveform. When the first diode conducts R93 is shunted by a predetermined amount, decreasing the slope. Each diode in turn decreases the slope until all the diodes are conducting and the triangular wave has reached its crest. The triangular wave starts down, the diodes stop conducting in turn until the triangular wave has reached its crest. The triangular wave starts down, the diodes stop conducting in turn until the triangular wave reaches the average level. The other half-cycle is formed in the same manner, but by the diodes that are biased to shape the negative excursion.

It can be shown that using seven segments to approximate one quarter cycle of the sinewave results in approximately 1/6% rms distortion. However, variations in the diodes limit the practical result to about 1% rms distortion.

In the triangular wave position of the FUNCTION selector switch the non-linear load consisting of the diode network is replaced by R95 so that the combination R94 and R95 is a simple linear divider for all voltage levels. It is adjusted to give equal sine and triangular wave peak magnitude. The squarewave is connected to the FUNCTION selector switch through the divider R59 and R22 which adjusts the average voltage of the squarewave to the voltage at the cathode of V4. In the squarewave position of the selector switch, R63 parallels R93B to adjust the amplitude of the squarewave to be equal to the amplitude of the sinewave and the triangular wave.

3-5 OUTPUT SYSTEM

The output system consists of three stages as shown in Figure 3-7. The first stage V18 is a dual triode acting as a pair of separate cathode followers. These cathode followers isolate the signal input from the output stage. Any dc unbalance at the output terminals can be corrected by varying R65.

The second stage V19 is a differential amplifier. The difference between the two signals at its grids appears at both plates in nearly equal magnitudes and 180° out of phase. This effect is due to the large common cathode resistance. In this stage amplification takes place and also the signal difference E minus F is converted to push-pull voltages. The third stage V20 is another pair of cathode followers. The signals appearing at the plates of V19 are

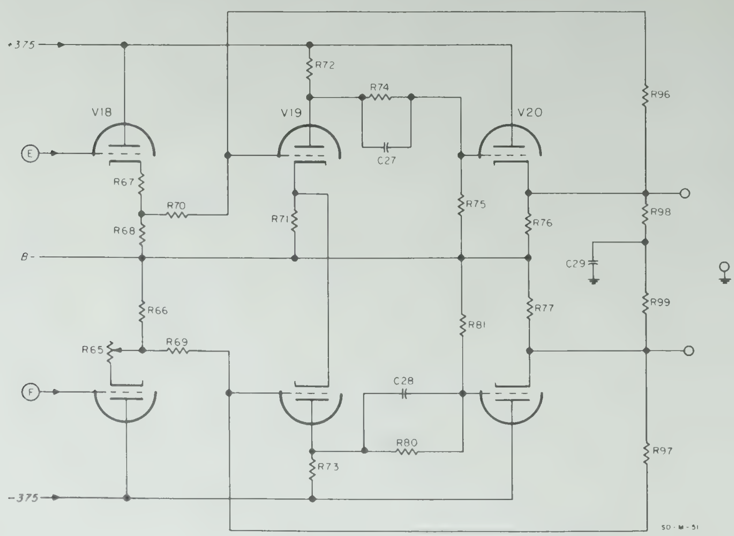


Figure 3-7. Output Amplifier System of Model 202A

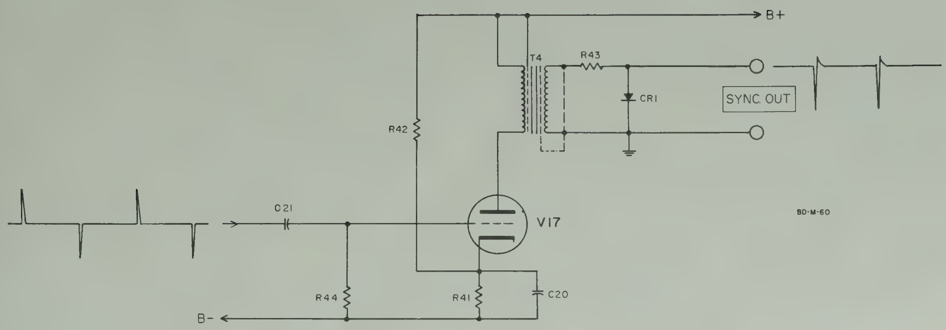


Figure 3-8. Sync Output Circuit of Model 202A

attenuated before being applied to the cathode follower grids. The small shunt capacitors on the upper sides of the dividers improve the high frequency response of the amplifier. The voltages appearing at the cathode follower output terminals are equal in magnitude and 180° out of phase. Negative feedback is used to reduce distortion, lower the output impedance and improve stability. This improved stability applies not only to the signal output, but to the dc level at the output terminals.

The symbol for chassis or ground is used for the first time in the output terminal network R98, R99 and C29. In all other description the reference level for operation has been B-, and in the Model 202A the B- line is completely isolated from the chassis. Thus, the

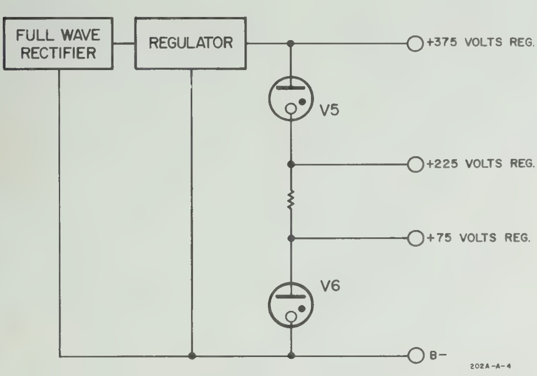


Figure 3-9. Model 202A Power Supply

chassis ground is available for whatever connection is desired. It is possible to consider the two output terminals as a transformer output and further to balance this apparent transformer chassis by making R98 equal to R99. The capacitor C29 insulates the apparent transformer secondary from ground. If single-ended operation is desired the ground connection can be tied to either output terminal without affecting the amplifier.

3–6. SYNC PULSE OUTPUT.

The output sync pulse is obtained from the bi-stable circuit V1 and V2. On the minus switching reference at the plate of multiar diode V3, one positive pulse and one negative pulse appear for every cycle of operation. These pulses are coupled to the grid of the sync pulse amplifier, V17, through an RC coupling which lowers the average voltage on the grid to B- . In the absence of pulses, V17 is biased to cut-off by the bleeder to B+. When a positive pulse appears at the grid, it momentarily turns V17 "on", thus, inducing a large voltage swing in the pulse transformer primary. The resistor and diode in the secondary remove the positive excursion, resulting in a negative pulse at the SYNC OUTterminals.

3–7. POWER SUPPLY.

The Power Supply is a full wave rectifier and regulator which supplies +375 volts. The +75 volt and +225 volt regulated outputs are taken from a voltage divider across the -375 volt supply. The main requirement on the three regulated voltages is very low impedance at low frequencies. Reasonable variations in the actual voltages do not affect the output frequency or waveform.

TABLE 4-0

TEST INSTRUMENTS REQUIRED

INSTRUMENT TYPE	MINIMUM REQUIRED SPECIFICATIONS	RECOMMENDED hp INSTRUMENTS
ELECTRONIC COUNTER	Period Measurement: Range: 0.00001 cps to 100 kc Accuracy: ± .3% ± 1 count Input Requirements: 0.1 v rms minimum Input Impedance: - megohm shunted by 50 pf.	hp 523C/ D
OSCILLOSCOPE	Vertical Amplifier: Sensitivity: 1 mv/cm Band Width: DC to 300 kc Balanced Input Sweep Sweep Range: 0.2 μsec/cm to 12.5 sec/cm	hp 130B
DISTORTION ANALYZER	Distortion Range: 20 cps to 20 kc Freq. Accuracy: ±2% Sensitivity: 0.3% fullscale Input: 1 volt rms	hp 330B
VACUUM TUBE VOLTMETER	AC Voltmeter: 0.5 to 300 v Accuracy: ±3% DC Voltmeter: 15 mv to 1500 v Accuracy: ±2% Ohmmeter: 10 ohms to 10 megohms	hp 410C
RESISTOR	±5%, 3.9 k ohms, 2 watt	

SECTION IV
MAINTENANCE

4-1 GENERAL

Most of the following analyzing and adjustment procedures require the measurement of dc voltages or the observation of waveforms. To obtain accurate results, use a voltmeter with an input resistance of 100 megohms or more. The ⓗⓟ Model 410B Vacuum Tube Voltmeter is recommended.

All dc voltages are measured with respect to B- and not with respect to the chassis. The B- points in the instrument are connected with black hook-up wire.

CAUTION

Isolate all test equipment from the main chassis or ground. Otherwise, both B- and one side of the output may be connected to the main chassis through the test equipment. If this happens, one cathode resistor in output stage V20 will be shorted and the tube will be severely damaged.

Whenever possible the instrument frequency should be set to approximately 50 cycles/sec. to permit the use of a capacitor in series with the ac voltmeter or oscilloscope to eliminate the dc component.

Interaction between most of the circuits of the Model 202A makes a fairly definite procedure for trouble shooting necessary. For example, a fault in the oscillator section may easily cause considerable voltage deviations in the output system. Therefore, it is more desirable to divide the instrument into five sections as follows and consider each in turn.

4-2 Power Supply
4-3 Function Generator
4-4 Sine Synthesizer and Function Selector
4-5 Output Amplifier
4-6 Sync Out

4-2 POWER SUPPLY

After power supply parts replacements or adjustments, a final check of regulated voltages should be made. See Power Supply Regulator Adjustments in paragraph 4-9.

TABLE 4-1

SYMPTOM	CAUSE AND/OR REMEDY
Instrument inoperative (Indicator lamp won't light, no output voltage).	Blown fuse, F1.
Instrument inoperative (Indicator lamp lights, no output voltage).	Measure resistance from V21 socket (pins 2 or 8) to B-. 55,000 ohms or more replace V21. If less than 55,000 ohms clear short circuit in filter or regulator circuits then replace V21.
Instrument inoperative (normal voltage at V21). (Extremely low or no voltage between V5, pin 5 and B-).	Defective 6AU5 tubes (V22, V23). Capacitor C6 short circuited.
Instrument inoperative (normal +375V regulated) (+225V regulated, off voltage).	Defective OA2 tube (V5).
(+75V regulated, off voltage)	Defective OA3 tube (V6).
Instrument inoperative (No +225 regulated +75 regulated voltages, V5 and/or V6 not ionized).	Open circuit in R62, R84, R85, R91, or R92.

4-3 FUNCTION GENERATOR (bi-stable circuit and integrator)

A. REPAIR ANALYSIS OF FUNCTION GENERATOR

If replacing tubes does not restore the triangle voltage, then a simple test should be made to determine whether the fault is in the integrator or the bi-stable circuit. This test is as follows:

1) Connect a high resistance dc voltmeter between B- and pin 3 of tube V17.

2) Set the RANGE switch to the X. 01 position. Disconnect the lead from the center lug of the variable resistor R58. Temporarily connect this lead to pin 5, V6 (+ 75 Reg.).

3) After this connection is made, the voltage indicated by the voltmeter should slowly climb until it is over 200 volts.

4) Remove the lead from the + 75 Reg. supply and connect it to pin 2, V5 (+ 225 regulated). The voltmeter indication should now drop slowly to less than 140 volts. Disconnect the lead from V5 and return it to the original connection on R58.

5) If the instrument meets the above voltage requirements, then the integrator section is functioning normally and the fault is confined to the bi-stable circuit. If the instrument does not pass the test, then the trouble is in the integrator.

After all defective parts have been replaced and the necessary adjustments made, an oscilloscope should be connected between pin 3, tube V17 and B- to see if a good triangular waveform is obtained on all ranges.

TABLE 4-2.

SYMPTOM	CAUSE AND/OR REMEDY
No output voltage (Power Supply Section normal, no triangle voltage between V17, pin 3 and B- on any range).	Replace V1, V2, V3, V15, V16, or V17. If tube replacement fails to cure the trouble, see analysis procedure following this chart.
Same symptoms as above on one or more ranges.	Check RANGE switch contacts, components, and connections. Check C14-C18 for excessive leakage.

TABLE 4-2. (CONT'D)

SYMPTOM	CAUSE AND/OR REMEDY
Same symptoms as above when frequency dial is set near low frequency end.	Try replacement tubes for V15, V16, and/or V17.
Triangle not linear.	Replace tubes V15, V16, V17. Check DC Balance.

4-4 SINE SYNTHESIZER AND FUNCTION SELECTOR

When the trouble has been corrected in the Sine Synthesizer and Function Selector, the following checks should be made to determine if the instrument is again functioning correctly.

1) Sine Wave - Observe the waveform between pin 2, V18 and B- with oscillator set to 50 cycles/sec. and the AMPLITUDE control at maximum. Set the FUNCTION switch in the SINE position. The waveform should be substantially sinusoidal and approximately 30 volts peak-to-peak. See Figure 3-6B.

Observe the waveform between pin 7, V18 and B- with the same conditions as above. The waveform should be similar to Figure 3-6C and approximately 1 volt peak-to-peak.

2) Triangular Wave - Observe the waveform between Pin 2, V18 and B- with the oscillator set to 50 cycles/sec. and the AMPLITUDE control at maximum. Set the FUNCTION switch in the TRIANGULAR position. The waveform should be triangular and approximately 30 volts peak-to-peak.

Observe the waveform between pin 7, V18 and B- with same conditions as above. The waveform should be triangular and approximately 1 volt peak-to-peak.

3) Square Wave - Observe the waveform between pin 7, V18 and B- with the oscillator set to 50 cycles/sec. and the AMPLITUDE control at maximum. Set the FUNCTION switch to the SQUARE position. The waveform should be square and approximately 30 volts peak-to-peak.

The dc voltage across the OUTPUT terminals should be adjustable to zero under any operating conditions by means of R65.

TABLE 4-3.

SYMPTOMS	CAUSE AND/OR REMEDY
Sinewave badly distorted.	Maladjustment of R49, R51, and R60 or defective diodes CR2 through CR13.
DC component at OUTPUT terminals independent of AMPLITUDE control setting or varied by AMPLITUDE control.	Maladjustment of R65, R54, and R118 or defective tubes V4, V18, V19, V20. See DC Balance Adjustment.

After adjustment or tube replacement, the amplifier should meet the following specifications:

--- The output voltage should not drop more than 2% when a 4000 ohm load is connected to the output.

--- The distortion should remain within specifications when the output is loaded with 4000 ohms or higher.

--- The peak-to-peak output voltage should be at least 30 volts (10.6 volts rms with a sinewave) when the output is loaded with 4000 ohms or higher.

4-5 OUTPUT AMPLIFIER

TABLE 4-4.

SYMPTOMS	CAUSE AND/OR REMEDY
Increased distortion when amplifier is loaded with 4000 ohms.	Replace V18, V19, V20. If distortion remains, turn off the power and measure resistance between internal chassis and main chassis. See paragraph 4-9.
DC voltage component exists across the OUTPUT terminals.	See paragraph 4-4.
Distortion increases appreciably with reduced AMPLITUDE control setting.	Replace variable resistor R93A, R93B.
Failure to deliver 10 volts rms sinewave output.	Adjust regulated B+ voltage. See paragraph 4-9.
Hum in output voltage.	Replace V18, V19, V20.
	Excessive hum from power supply. See paragraph 4-9.

4-6 SYNC OUT

Specifications call for a negative sync pulse of 10 volts peak with a duration less than 5 microseconds. The sync pulse occurs at the sinewave crest and at corresponding positions on other waveforms.

TABLE 4-5.

SYMPTOMS	CAUSE AND/OR REMEDY
No sync pulse (Check for negative pulse with oscilloscope and with Model 202A set for highest frequency).	Replace V17.
Large overshoot.	Replace CR1.

4-7 TUBE REPLACEMENT

Any tube with standard JETEC characteristics can be used for replacement purposes.

Whenever a tube is replaced, that part of the instrument which might be affected by the change must be tested and if necessary, adjusted to be within specifications. See paragraph 4-8, Tube Replacement Chart.

4-8 TUBE REPLACEMENT CHART

TABLE 4-6.

TUBE	EFFECT	READJUSTMENT
V1, V2	None. Variations in bottoming voltage eliminated by clamps V7 and V8.	None.
V3	Frequency shift and distortion increase due to contact potential variations.	Min. Distortion and Correct Freq. Adj.
V4	DC output level shift, probably as a function of amplitude control setting.	DC Bal. Adj.
V5, V6	Possible change in frequency, distortion, or dc balance from change in regulated voltages.	Power Supply. DC Bal Adjust. Minimum Distortion and Correct Freq. Adjust.
V7, V8	Same effect as change in V3 possible, but to much less degree.	Min. Distortion and Correct Freq. Adj.
V15, V16, V17	Frequency change and unbalance of triangle.	Min. Distortion and Correct Freq. Adj.
V18, V19, V20	Change in dc output component, independent of AMPLITUDE control setting.	Set dc output component to zero by R65, with amplitude control min.
V21	No effect	None.
V22, V23, V24, V25	Possible change in +375 and +225 regulated voltages.	Carry out procedure under "Power Supply Regulator Adjustment". Paragraph 4-9.

4-9 POWER SUPPLY REGULATOR ADJUSTMENT

Resistance measured between inner and outer chassis should be at least two megohms with OUTPUT terminals disconnected from panel ground or a load. This resistance check should be made before starting the following adjustment procedure:

1) Connect the shorting strap between the lower output terminal and chassis ground. Connect the dc voltmeter between B- and the inner chassis. The voltmeter must not be grounded and the common terminal should be connected to B-.

2) Connect the 202A to the power line and turn on. The voltmeter indication should be between +190 and +230 volts with line voltage set to 115 volts.

3) Measure the regulated output voltage between B- and pin 2 of tube V5. Adjust control R11 to give a voltage of +225 volts.

4) Measure the voltage between pin 5 of tube V5 and B-. This voltage should be about +375 volts. Variations in OA3 tubes can cause this voltage to be as low as 365 or as high as 393.

5) Measure the voltage between pin 5 of tube V6 and B-. This voltage should be about + 75 volts. Variations in OA3 tubes can cause this voltage to fall at any point between 68 and 85 volts.

6) Repeat step 3 if you replace either V5 or V6. The characteristics of cold-cathode regulator tubes drift during about the first 72 hours of operation. This drift can affect the 202A output. A 72 hour aging is recommended for a new tube for either V5 or V6.

7) Test the regulated output voltage at pin 5 of tube V5 while varying line voltage between 103 and 127 volts. The regulated voltage will normally not change by more than ±1%. Check power supply tubes and components if the change is excessive.

4-10 THEORY OF DC BALANCE AND DISTORTION ADJUSTMENTS

The output AMPLITUDE control is located at the input to the output amplifier. If the dc component at the output terminals is to be zero for all settings of the AMPLITUDE control the dc levels at the ends of the AMPLITUDE control must be the same and also equal to the average level of the input wave. From the schematic wiring diagram, it is seen that the common connection between the two sections of the control is connected to the cathode of V4. The level of this point can be adjusted to the desired value by R54. The signal impedance of this point is very low compared with the magnitude of the AMPLITUDE control impedance, and therefore, the cathode of V4 has virtually zero signal.

When R49, R51, R54, and R60 are adjusted properly, there is no dc component across either section of the AMPLITUDE control.

When the FUNCTION switch is in the squarewave position, there is no signal input to one section of the AMPLITUDE control, hence, the tap on that section merely carries the constant bias level set by the cathode of V4. The other section is connected through a network to the clamp section of the bistable circuit. R22 of this network adjusts the average level of the squarewave applied to the amplitude control to the same value as the cathode of V4.

The dc levels at the input to the amplifier are independent of AMPLITUDE control setting. The dc levels of the two output terminals may be adjusted to be equal by R65. Control R65 varies the dc level of the signal on one grid of the second stage of the amplifier. When these adjustments are made, the dc component between the output terminals will remain at a very low value, independent of amplitude setting or waveform selected.

Control R49 varies the level to which the output of the integrator rises in a positive direction and R51 varies the level of the negative excursion. The bias levels of the shaper diodes are not variable and therefore, the triangle input to the shaper can have one and only one correct magnitude and average level.

Figure 4-2 shows the situation at the shaper when the two reference levels are properly adjusted. Figure 4-2B shows the effect of having the reference levels adjusted for too large a magnitude, but with the proper average value. Figure 4-2C shows the effect of having reference levels adjusted for a triangle of the proper magnitude, but incorrect average level. This indicates a close relationship between correct frequency calibration and minimum distortion. In fact, the two conditions are simultaneously satisfied by optimum settings of the same adjustments.

4-11 DC BALANCE AND DISTORTION ADJUSTMENTS

The following test procedure requires a dc voltmeter with an input resistance of at least 100 megohms such as an ⓗⓟ Model 410B. In addition, the voltmeter must not be grounded as the common side of the meter must be connected to points within the 202A that are not at ground potential. A Distortion Analyzer and an Oscilloscope will also be required.

A 20 minute warm-up is recommended before you start this procedure. You should also adjust the power supply as outlined in paragraph 4-9.

1) Adjust the insulated 410B voltmeter to indicate 0.5 on the 1 volt range with the dc leads shorted. Use either the "+" or the "-" position of the SELECTOR switch -- whichever one will permit the 0.5 setting with the ZERO ADJ. control. This meter indication will be called "0 volts" in the remaining portion of this procedure.

2) Connect the COMMON lead from the voltmeter to the common junction of AMPLITUDE controls R93A and R93B (violet wire).

3) Connect the DC volts probe to the opposite end of R93A. This is a slate wire connected to the AMPLITUDE control.

4) Set the FUNCTION switch to TRIANGULAR and adjust R54 for a voltmeter indication of "0 volts".

5) Move the DC volts probe to the arm of R118 and adjust R118 for an indication of approximately "0 volts".

6) Set the AMPLITUDE control to minimum (maximum CCW) and move the voltmeter leads to the red OUTPUT terminals.

7) Adjust R65, located behind a hole in the panel near the OUTPUT terminals, for an indication of "0 volts".

8) Set R119, located near V1 and T2, to the middle of its range.

9) Disconnect the voltmeter and connect equipment as shown in Figure 4-1.

10) Set the FREQUENCY dial to 10, the RANGE switch to X10 (100 cps), FUNCTION selector to SINE, and the AMPLITUDE control for an output of approximately 10 volts rms.

11) Adjust R49 and R51 to eliminate the points or spikes at the ends of the Oscilloscope pattern. Adjustment of these controls will shift the output frequency, you should follow the frequency shift with the Distortion Analyzer. Adjust the Distortion Analyzer sensitivity as necessary to obtain a useful pattern on the Oscilloscope (see Figure 4-3).

12) Adjust R60 for minimum distortion as indicated on the Distortion Analyzer. Repeat steps 11 and 12 until the distortion measured is at least 40 db below the output voltage (1%).

13) Connect the voltmeter COMMON lead to the common junction of AMPLITUDE controls R93A and R93B (violet wire).

14) Connect the DC volts probe to the opposite end of R93B. This is a green wire connected to the AMPLITUDE control.

15) Switch the FUNCTION selector to TRIANGULAR and note the voltmeter indication (0.5 on 0-1 scale is "0 volts"). Adjust R49 to reduce the dc voltage to one-half of its initial value, then adjust R51 to remove the remaining dc voltage. The voltmeter should now indicate "0 volts".

16) Set the FUNCTION selector to SINE and adjust R118 for a voltmeter indication of "0 volts".

17) Verify the distortion in the output sine wave at 100 cps, first on the X10 RANGE with the FREQUENCY dial at 10, then on the X100 RANGE with the FREQUENCY dial at 1. If the distortion indications are not approximately identical, careful adjustment of R119 will lower the 100 cps distortion on the X100 RANGE.

18) Connect the voltmeter COMMON lead to the common junction of AMPLITUDE controls R93A and R93B (violet wire). Connect the DC volts probe to the green wire on the opposite end of R93B.

19) Set the FUNCTION selector to SQUARE and the RANGE switch to X10. Adjust R22 for a voltmeter indication of "0 volts".

20) Any dc between the red OUTPUT terminals with the AMPLITUDE control at minimum may be eliminated by adjusting R65 (behind the hole in the panel). This voltage should vary less than ±0.5 volts when the AMPLITUDE control is rotated through its full range.

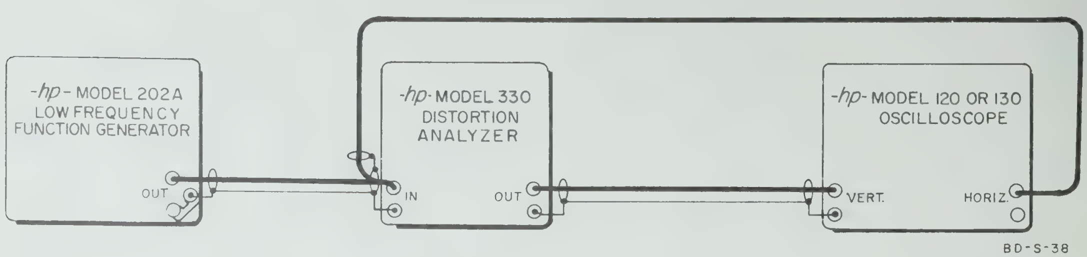


Figure 4-1. Minimum Distortion and Frequency Adjustment Instrumentation

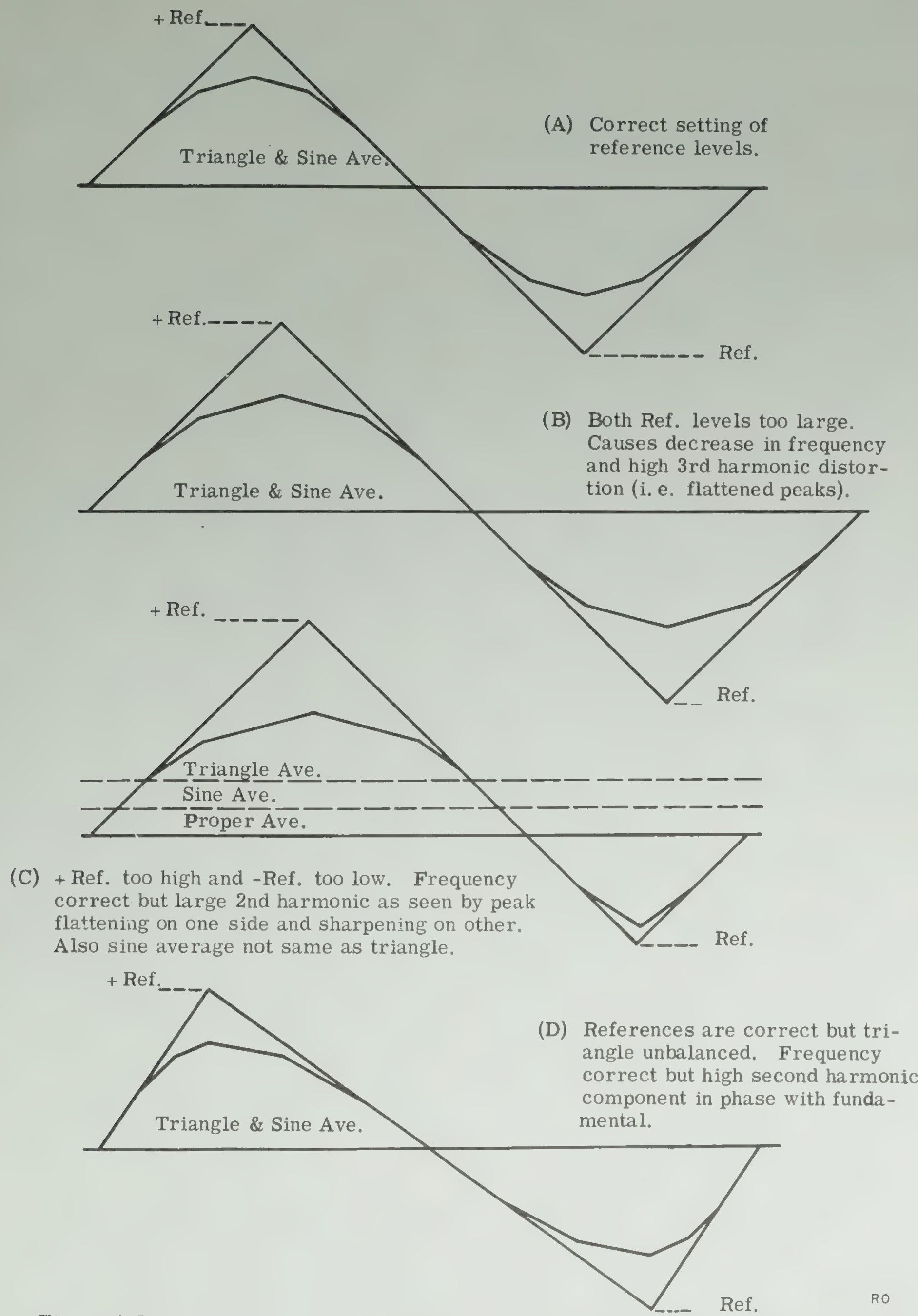
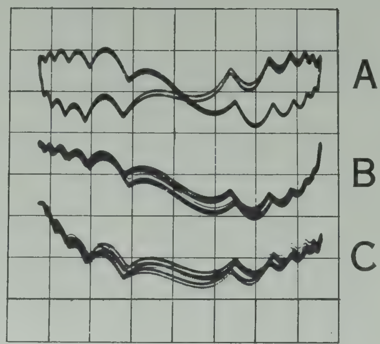


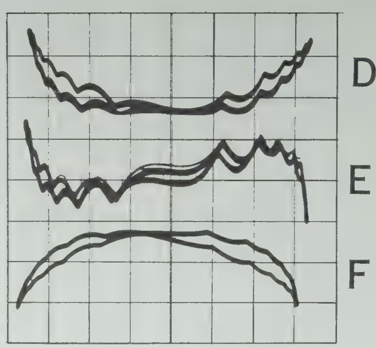
Figure 4-2. Effect of Triangle Maladjustment on Distortion and Frequency. Ten-Segment Approximations Used for Clarity.



(A) R60 and R119 misadjusted

(B) R51 misadjusted

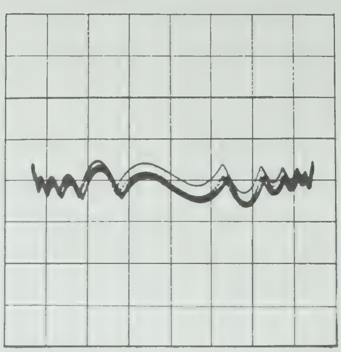
(C) R49 misadjusted



(D) R49 and R51 misadjusted in same direction

(E) R49 and R51 misadjusted

(F) R49 and R51 misadjusted in opposite direction of pattern D above



Typical adjusted pattern for minimum distortion and correct frequency

Figure 4-3. Patterns Showing the Adjustments of R49, R51, R60 and R119 to Obtain Minimum Distortion and Correct Frequency

4-12 ADJUST SQUAREWAVE AMPLITUDE

Adjust control R63 to produce an output squarewave with the same peak-to-peak amplitude as the sine and triangular output waveforms.

4-13 FREQUENCY RATIO AND CALIBRATION PROCEDURE

The following procedure is intended for use after replacement of the Range Switch or any of the frequency determining components on the Range Switch. This procedure is also required following replacement of frequency determining potentiometer R58.

1) Remove the cabinet or top and bottom instrument covers.

2) Check that the upper and lower dial stops fall about an equal distance outside the upper and lower dial calibration marks. Correct the dial setting, if necessary, by rotating the dial on the dial mounting hub. The dial stops and not the potentiometer mechanical stops should be limiting dial travel.

3) Turn the 202A on, set the line voltage to 115 volts, turn the FUNCTION switch to "SQUARE", and allow at least a 1 hour warm-up period.

4) Adjust power supply, then adjust DC Balance and Distortion.

5) Determine the ratio between the two frequencies obtained with the frequency dial at "0. 8" and "12" with the RANGE switch at "X1".

Frequency determination is most easily accomplished by measuring the period of the unknown frequency. An electronic counter such as ⓗⓟ Model 522B, 523B, or 524B will be needed. A frequency of 0. 8 cps has a period of 1250 milliseconds while 12 cps has a period of 83. 3 milliseconds.

6) The ratio obtained in step 5 must be 15 to 1. Adjust by loosening the coupler between the dial and potentiometer (R58) shafts. See Figure 4-4 for coupler access hole location. Rotate one shaft with respect to the other to obtain a period of 83. 3 milliseconds with a dial reading of 12. Tighten both set screws in the coupler.

7) Set the frequency dial to 0. 8 and adjust control R109 to obtain a period of 1250 milliseconds. Check the setting made in step 6 and, if necessary, repeat step 6.

If R109 has insufficient range, center the control mechanically and repeat steps 6 and 7. This will electrically center the adjustment range of R109 which can then be used to make any final adjustments.

8) Check calibration of the "X1" range. The output frequency should be within ±2% of the dial reading over the entire range. Adjust R26B if necessary.

9) Check the calibration of the other ranges. Adjust R24B for the "X. 01" range, R25B for the "X. 1" range, R27B for the "X10" range and R28B for the "X100" range.

On the "X100" range only, adjust C33 to calibrate the high end of the band.

10) Replace the cabinet or the top and bottom cover.

4-14 REPLACEMENT OF R58 POTENTIOMETER

Replacement of the frequency control potentiometer involves two basic operations:

1) The mechanical procedure for replacing a defective potentiometer with a new one.

2) The necessary electrical adjustments described in paragraph 4-13.

All necessary specialized instructions are included with the replacement potentiometer.

4-15 PERFORMANCE CHECK

4-16. OUTPUT VOLTAGE AND WAVEFORM CHECK.

1) Connect test setup as shown in figure 4-4, including a 3.9K ohm shunt resistor across the OUTPUT terminals of Model 202A.

2) Set Model 202A controls as follows:

RANGE	X10
FREQUENCY DIAL	10 (100 cps)
AMPLITUDE	full cw
FUNCTION	SINE

3) Set oscilloscope VERTICAL SENSITIVITY to 5 volts/cm.

4) Sinewave observed should be sinusoidal and have an amplitude of at least 30 volts peak-to-peak.

5) Set FUNCTION to TRIANGULAR.

6) Wave observed should be triangular and have an amplitude of at least 30 volts peak-to-peak.

7) Set FUNCTION to SQUARE.

8) Square wave observed should have an amplitude of at least 30 volts peak-to-peak.

4-17. SYNC PULSE CHECK.

1) Connect test setup as shown in figure 4-4, except oscilloscope is to be connected to SYNC. OUT on Model 202A and not to OUTPUT.

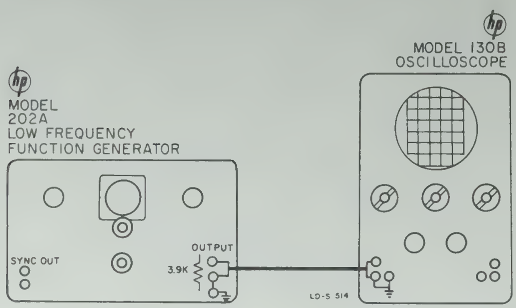


Figure 4-4. Output Voltage and Sync Pulse Test Setup

2) Set RANGE to X100 and FREQUENCY DIAL to 10 (1000 cps).

3) Set oscilloscope VERTICAL SENSITIVITY to 5 volts/cm and SWEEP TIME to 1 microsecond/cm.

4) The negative pulse observed should be less than 5 microsec duration and have an amplitude equal to or greater than 10 volts.

4-18. SINE WAVE DISTORTION CHECK.

1) Connect test setup as shown in figure 4-5, including a 3.9K ohm shunt resistor across the OUTPUT terminals of Model 202A.

2) Set Model 330B/C/D controls as follows:

INPUT . . . . AF
FREQUENCY RANGE X1
FREQUENCY DIAL . . . . 100 cps
FUNCTION . . . . METER
METER RANGE . . . . 30 RMS VOLTS

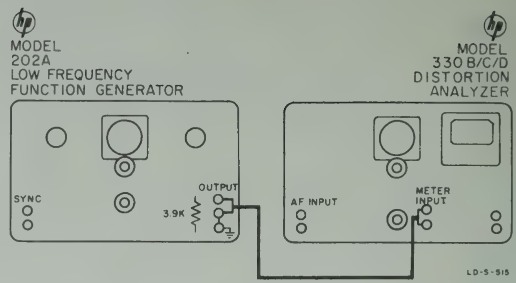


Figure 4-5. Sine Wave Distortion Test Setup

3) Set Model 202A controls as follows:
RANGE X10
FREQUENCY DIAL . . . . 10 (100 cps)
FUNCTION . . . . SINE
AMPLITUDE adjusted for 10.6 volts output (read on Model 330B/C/D).

4) Disconnect cable from METER INPUT and reconnect it to AF INPUT.

5) Set FUNCTION to SET LEVEL and METER RANGE to 100%.

6) Adjust INPUT SENSITIVITY for 100% on the 10 scale (full scale is 100%).

7) Set FUNCTION to DISTORTION.

8) Tune Model 330B/C/D for null.

9) Set METER RANGE to 3% and retune for null. Reading should be less than 1 on the 3 scale (full scale is 3%).

10) On Model 202A change RANGE to X100 and FREQUENCY to 1 (100 cps). Repeat steps 1 through 9 at this frequency. Reading should be less than 2.

4-19. DIAL ACCURACY CHECK.

1) Connect test setup as shown in figure 4-6.

2) Allow 1/2 hour warmup period.

3) Set Model 202A controls as follows:
RANGE X100
FREQUENCY . . . . 12 (1200 cps)
FUNCTION . . . . SQUARE

4) Set Model 523C/D for period measurement as follows:
FUNCTION SELECTOR . . . . PERIOD
TIME UNIT . . . . µSEC

5) Model 523C/D should read between 816 and 850.

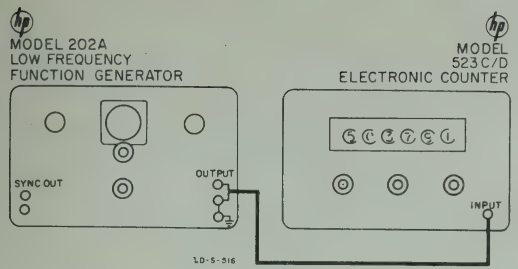


Figure 4-6. Dial Accuracy Test Setup

6) Set Model 202A RANGE to X10 (120 cps) and Model 523C/D TIME UNIT to MILLISEC.

7) Counter should read between 8.16 and 8.50.

8) Set Model 202A RANGE to X1 and FREQUENCY dial to 1.4 (1.4 cps).

9) Counter should read between 699.9 and 728.5 .

10) Set Model 202A RANGE to X1 (.14 cps).

11) Counter should read between 6999.9 and 7284.7 .

12) Set Model 202A RANGE to X1, FREQUENCY dial to .8 (.008 cps) and Model 523C/D TIME UNIT to SEC.

13) Counter should read between 121.25 and 128.75. Due to such a low frequency the counter may not start its count for approximately 2 min and 5 sec.

4-20. NOISE CHECK

1) Connect test setup as shown in Figure 4-4.

2) Set Model 202A controls as follows:

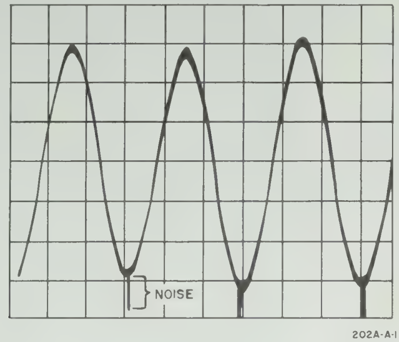
RANGE X10
FREQUENCY . . . . 100 (1000 cps)
FUNCTION . . . . SINE

3) Set Model 130B controls as follows:

VERTICAL SENSITIVITY 5 volts/CM
SWEEP TIME 1 Microsecond/CM

4) Adjust 202A AMPLITUDE control for 6 centimeters on Model 130B Oscilloscope as per Figure 4-7. (Note: From 5.0 volts per cm to 5.0 milli - volts per cm is equal to 60 DB.

5) The noise present on the signal should be less than .3 cm.



4-7. Noise: Oscilloscope Display

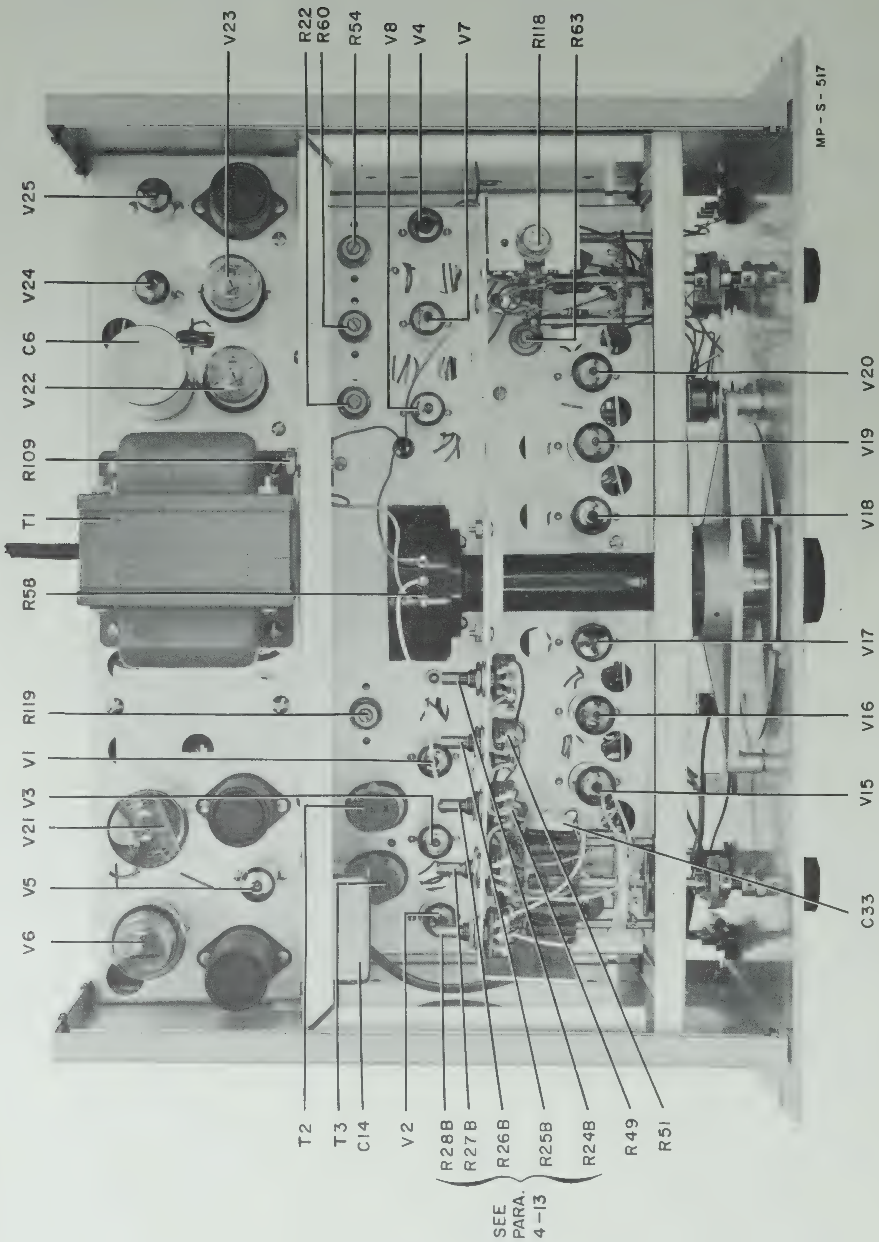


Figure 4-8 Model 202A Top View Cover Removed

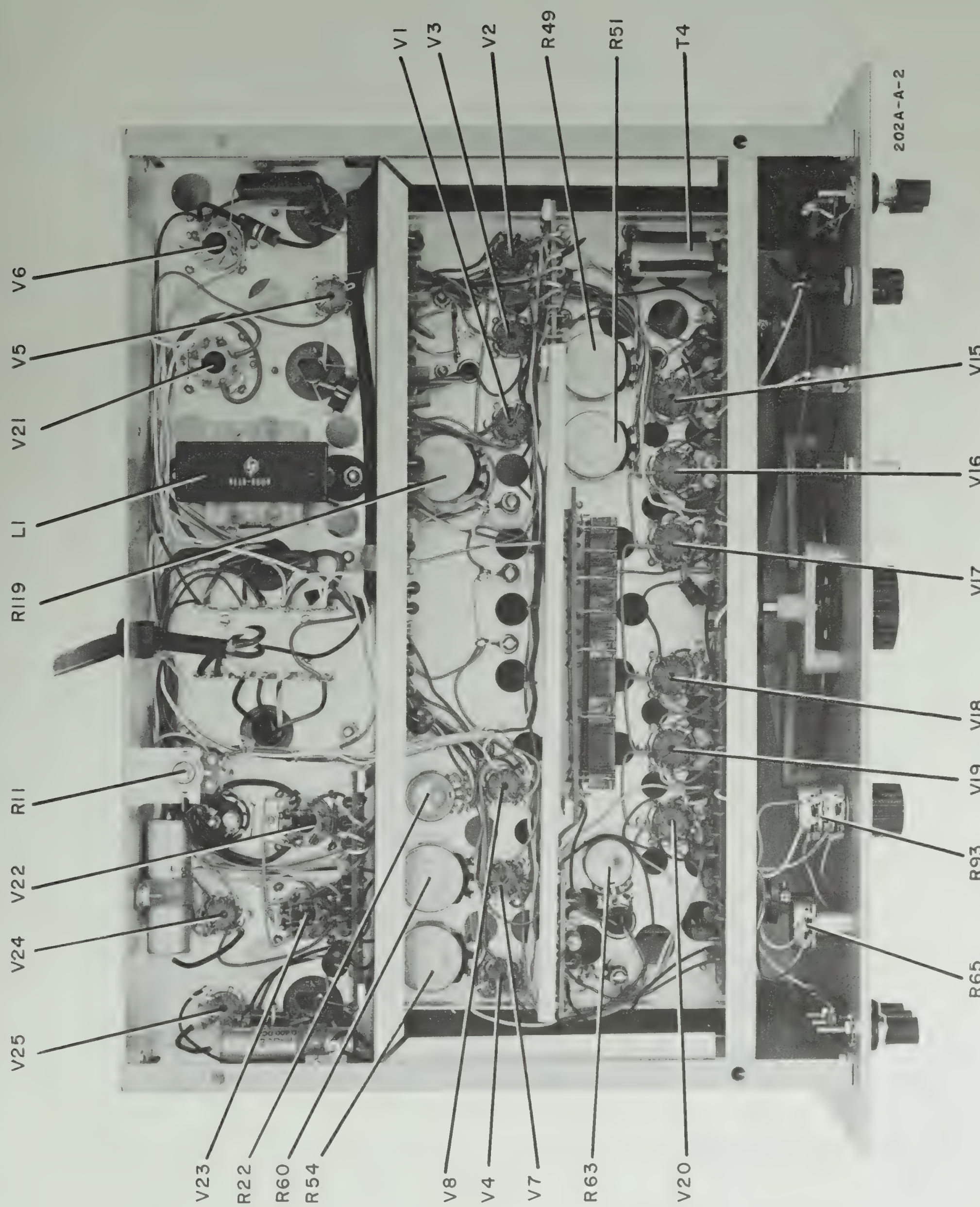
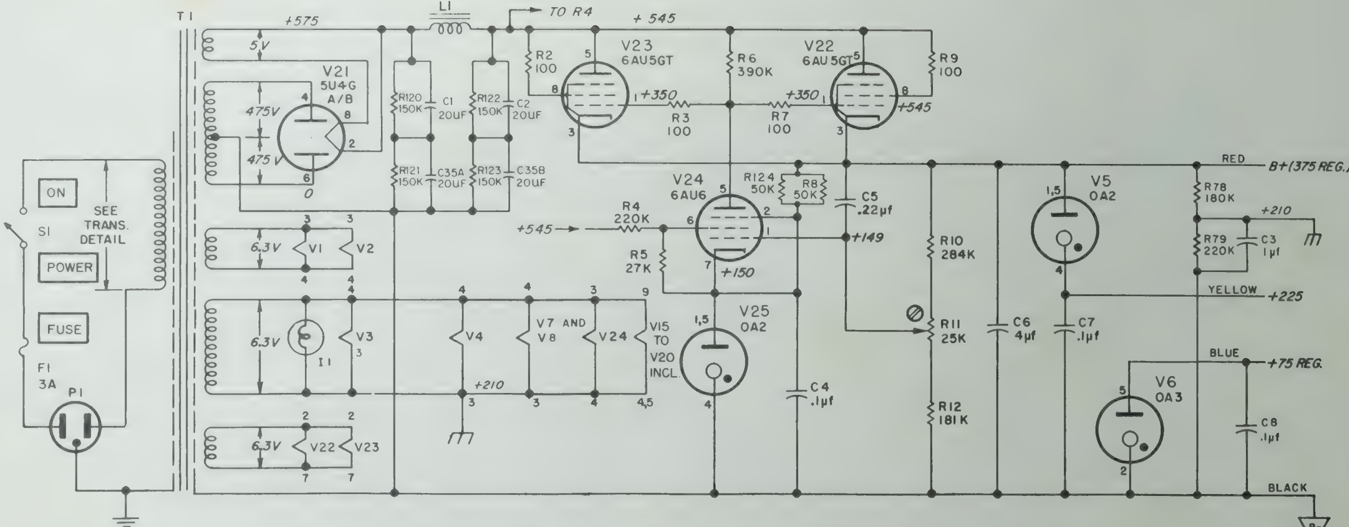


Figure 4-9. Model 202A Bottom View Bottom Plate Removed



NOTES: (APPLY TO FUNCTION GENERATOR & AMPLIFIER SECTION AS WELL AS TO POWER SUPPLY SECTION).

CONDITIONS OF DC VOLTAGE MEASUREMENT:

1. 115/230V, 50/1000∿ POWER SUPPLY
2. MEASURED BETWEEN THE INDICATED POINTS AND B- WITH A VOLTMETER OF 122MEGOHMS INPUT RESISTANCE. (B- IS ANY BLACK LEAD IN POWER SUPPLY EXCEPT T1 PRIMARY START.)
3. PANEL CONTROLS SET AS FOLLOWS:
   RANGE AT X10.
   FREQUENCY AT 5.
   FUNCTION AT SINE.
   AMPLITUDE AT MAX.

○ PANEL CONTROL

⊘ SCREWDRIVER ADJ.

* ELECTRICAL VALUE ADJUSTED AT THE FACTORY. AVERAGE VALUE SHOWN. PART MAY BE OMITTED.

K = 1000 OHMS

M = 1 MEGOHM

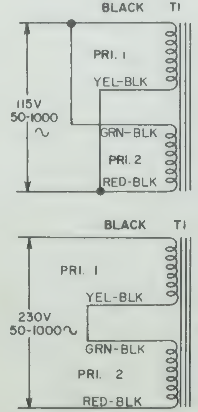
⏚ MAIN (EXTERNAL) CHASSIS, ISOLATED FROM POWER SUPPLY VOLTAGES.

⏊ INTERNAL CHASSIS, ONE POINT CONNECTION TO DIVIDER R78 & R79

B- (POWER SUPPLY RETURN) IS NOT CONNECTED TO CHASSIS.

CAPACITY IN µµF UNLESS OTHERWISE NOTED.

202A - 325



TRANSFORMER DETAIL

Figure 4-9. Model 202A Power Supply

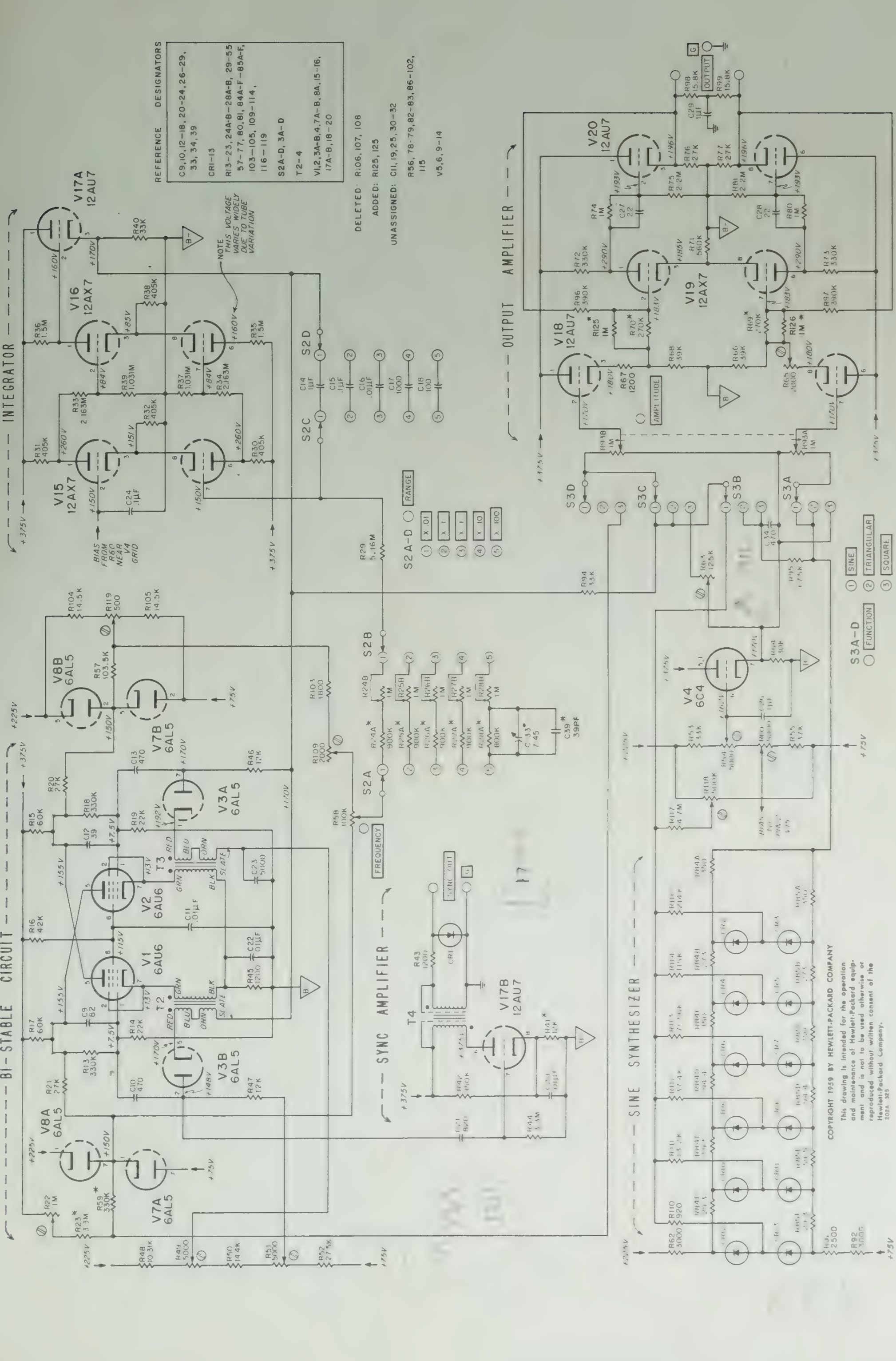


Figure 4-10. Model 202A Function Generator and Amplifier

SECTION V
REPLACEABLE PARTS

5-1. Introduction.

5-2. This section contains information for ordering replacement parts. Table 5-1 lists parts in alpha-numerical order of their reference designators and indicates the description and hp stock number of each part, together with any applicable notes. Table 5-2 lists parts in alpha-numerical order of their hp stock numbers and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

c. Manufacturer's stock number.

d. Total quantity used in the instrument (TQ column).

e. Recommended spare part quantity for complete maintenance during one year of isolated service (RS column).

5-3. Miscellaneous parts not indexed in Table 5-1 are listed at the end of Table 5-2.

5-4. Ordering Information

5-5. To order a replacement part, address order or inquiry either to your Hewlett-Packard field office or to:

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

or, in Western Europe, to:

Hewlett-Packard S. A.
54-54bis Route Des Acacias
Geneva, Switzerland

5-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

5-7. To order a part not listed in Table 5-1 and 5-2, give a complete description of the part and include its function and location.

REFERENCE DESIGNATORS

A	= assembly	F	= fuse	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
B	= motor	FL	= filter	Q	= transistor	W	= cable
C	= capacitor	J	= jack	R	= resistor	X	= socket
CR	= diode	K	= relay	RT	= thermistor	XF	= fuseholder
DL	= delay line	L	= inductor	S	= switch	XDS	= lampholder
DS	= device signaling (lamp)	M	= meter	T	= transformer	Z	= network
E	= misc electronic part	MP	= mechanical part				

ABBREVIATIONS

a	= amperes	elect	= electrolytic	mtg	= mounting	rot	= rotary
bp	= bandpass	encap	= encapsulated	my	= mylar	rms	= root-mean-square
bwo	= backward wave oscillator	f	= farads	NC	= normally closed	rmo	= rack mount only
c	= carbon	fxd	= fixed	Ne	= neon	s-b	= slow-blow
cer	= ceramic	Ge	= germanium	NO	= normally open	Se	= selenium
cmo	= cabinet mount only	grd	= ground (ed)	NPO	= negative positive zero (zero temperature coefficient)	sect	= section(s)
coef	= coefficient	h	= henries	nsr	= not separately replaceable	Si	= silicon
com	= common	Hg	= mercury	obd	= order by description	sil	= silver
comp	= composition	impg	= impregnated	p	= peak	sl	= slide
conn	= connection	incd	= incandescent	pc	= printed circuit board	td	= time delay
crt	= cathode-ray tube	ins	= insulation (ed)	pf	= picofarads = 10^{-12} farads	TiO_2	= titanium dioxide
dep	= deposited	K	= kilo = 1000	pp	= peak to peak	tog	= toggle
EIA	= Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by hp stock numbers.	lin	= linear taper	piv	= peak inverse voltage	tol	= tolerance
		log	= logarithmic taper	pos	= position (s)	trim	= trimmer
		m	= milli = 10^{-3}	poly	= polystyrene	twt	= traveling wave tube
		M	= megohms	pot	= potentiometer	var	= variable
		ma	= milliamperes	rect	= rectifier	w/	= with
		μ	= micro = 10^{-6}			W	= watts
		minat	= miniature			ww	= wirewound
		mfgl	= metal film on glass			w/o	= without
		mfr	= manufacturer			*	= optimum value selected at factory, average value shown (part may be omitted)

Table 5-1. Index by Reference Designator

Circuit Reference	Ⓗ Stock No.	Description	Note
C1, 2	0180-0011	Capacitor: fixed, electrolytic, 20 μf, 450 vdcw	
C3	0160-0016	Capacitor: fixed, paper 1 μf ± 20%, 400 vdcw	
C4	0160-0013	Capacitor: fixed, paper, 0.1 μf ± 10%, 400 vdcw	
C5	0160-0018	Capacitor: fixed, paper, .22 μf ± 10%, 400 vdcw	
C6	0160-0077	Capacitor: fixed, paper 4 μf ± 10%, 600 vdcw	
C7, 8		Same as C4	
C9	0140-0006	Capacitor: fixed, mica, 82 pf ± 10%, vdcw	
C10	0140-0027	Capacitor: fixed, mica, 470 pf ± 10%, 500 vdcw	
C11	0150-0012	Capacitor: fixed, ceramic .01 μf, tol. ±20%	
C12	0140-0021	Capacitor: fixed, mica, 39 pf ± 10%, 500 vdcw	
C13		Same as C10	
C14	0170-0059	Capacitor: fixed, 1 μf ± 5%, 400 vdcw	
C15	0170-0001	Capacitor: fixed, polystyrene, .1 μf ± 5%, 400 vdcw	
C16	0170-0023	Capacitor: fixed, polystyrene, .01 μf ± 5%, 600 vdcw	
C17	0140-0018	Capacitor: fixed, silver mica, .001 μf ± 5%, 500 vdcw	
C18	0150-0007	Capacitor: fixed, ceramic, 100 pf ± 5%, 500 vdcw	
C19		This circuit reference not assigned	
C20		Same as C11	
C21	0140-0010	Capacitor: fixed, mica, 820 pf ± 10%, 500 vdcw	
C22		Same as C11	
C23	0150-0014	Capacitor: fixed, ceramic, .005 μf, 500 vdcw	

See introduction to this section

Table 5-1. Index by Reference Designator (Cont'd)

Circuit Reference	ⓗⓟ Stock No.	Description	Note
C24		Same as C4	
C25		This circuit reference not assigned	
C26		Same as C4	
C27, 28	0140-0026	Capacitor: fixed, mica, 22 pf ± 10%, 500 vdcw	
C29		Same as C3	
C30, 31, 32		These circuit references not assigned	
C33	0130-0001	Capacitor: variable, ceramic, 7-45 pf, 500 bdcw. Optimum value selected at factory. Average value shown.	
C34		Same as C10	
C35	0180-0012	Capacitor: fixed, electrolytic, 2 section 20 μf/sect., 450 vdcw	
CR1	1910-0016	Diode	
CR2-13	1901-0033	Diode, silicon	
F1	2110-0003 2110-0005	Fuse, cartridge: 3 amp (115V) Fuse, cartridge: 1.6 amp (230V)	
I1	2140-0012	Lamp, incandescent: 6-8V, 2 pin base GE#12	
L1	9110-0004	Inductor: 6H at 125 MA, 264 ohms	
P1	8120-0015	Power Cable	
R1		This circuit reference not assigned	
R2, 3	0687-1011	Resistor: fixed, composition, 100 ohms ±10%, 1/2 W	
R4	0693-2241	Resistor: fixed, composition, 220,000 ohms ±10%, 2 W	
R5	0690-2731	Resistor: fixed, composition, 27,000 ohms ±10%, 1 W	
R6	0690-3941	Resistor: fixed, composition, 390,000 ohms ±10%, 1 W	
R7		Same as R2	
R8	0813-0032	Resistor: Fixed, wirewound, 50,000 ohms ±10%, 10 W	

See introduction to this section

Table 5-1. Index by Reference Designator (Cont'd)

Circuit Reference	ⓗⓟ Stock No.	Description	Note
R9		Same as R2	
R10	0730-0083	Resistor: Fixed, deposited carbon, 284,000 ohms ±1%, 1 W	
R11	2100-0009	Resistor: variable, composition, linear taper, 25,000 ohms ±20%, 1/3 W	
R12	0730-0077	Resistor: Fixed, deposited carbon, 181,000 ohms ±1%, 1 W	
R13	0690-3341	Resistor: fixed, composition, 330,000 ohms ±10%, 1 W	
R14	0690-2231	Resistor: fixed, composition, 22,000 ohms ±10%, 1 W	
R15	0813-0033	Resistor: fixed, silicon, 60,000 ohms ±10%, 5 W	
R16	0813-0031	Resistor: fixed, wirewound, 42,000 ohms ±10%, 5 W	
R17		Same as R15	
R18		Same as R13	
R19		Same as R14	
R20, 21		Same as R5	
R22	2100-0435	Resistor: variable, composition, linear taper, 1 megohm ±30%, 1/4 W	
R23	0690-3351	Resistor: fixed, composition, 3.3 megohms ±10%, 1 W Optimum value adjusted at factory. Average value shown.	
R24 thru R28		These circuit references not assigned	
R24A thru R27A	0730-0103	Resistor: fixed, deposited carbon, 900,000 ohms ±1% Optimum value selected at factory. Average value shown.	
R28A	0730-0100	Resistor: fixed, deposited carbon 800,000 ohms ±1% Optimum value selected at factory. Average value shown.	
R24B thru R28B		Same as R22	
R29	0730-0126	Resistor: fixed, deposited carbon, 5.16 megohms ±1% 1 W	

See introduction to this section

Table 5-1. Index by Reference Designator (Cont'd)

Circuit Reference	ⓗⓟ Stock No.	Description	Note
R30 thru R32	0730-0088	Resistor: fixed, deposited carbon, 405,000 ohms ±1%, 1 W	
R33, 34	0730-00113	Resistor: fixed, deposited carbon, 2.163 megohms ±1%, 1 W	
R35, 36	0690-1551	Resistor: fixed, composition, 1.5 megohms ±10%, 1 W	
R37	0730-0106	Resistor: fixed, deposited carbon, 1.031 megohm ±1%, 1 W	
R38		Same as R31	
R39		Same as R37	
R40	0693-3331	Resistor: fixed, composition, 33,000 ohms ±10%, 2 W	
R41	0687-1231	Resistor: fixed, composition, 12,000 ohms ±10%, 1/2 W Optimum value selected at factory. Average value shown.	
R42	0693-1541	Resistor: fixed, composition, 150,000 ohms ±10%, 2 W	
R43	0690-1221	Resistor: fixed, composition, 1200 ohms ±10%, 1 W	
R44	0690-3351	Resistor: fixed, composition, 3.3 megohms ±10%, 1 W	
R45		Same as R43	
R46, 47	0690-1231	Resistor: fixed, composition, 12,000 ohms ±10%, 1 W	
R48	0730-0031	Resistor: fixed, deposited carbon, 10.31K ohms ±1%, 1 W	
R49	2100-0006	Resistor: variable, wirewound, linear taper, 5000 ohms ±10%, 2 W	
R50	0730-0034	Resistor: fixed, deposited carbon, 14,400 ohms ±1%, 1 W	
R51		Same as R49	
R52	0730-0044	Resistor: fixed, deposited carbon, 27,500 ohms ±1%, 1 W	
R53	0730-0048	Resistor: fixed, deposited carbon, 33,000 ohms ±1%, 1 W	
R54		Same as R49	

See introduction to this section

Table 5-1. Index by Reference Designator (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
R55	0730-0049	Resistor: fixed, deposited carbon, 37,000 ohms ±1%, 1 W	
R56		This circuit reference not assigned	
R57	0730-0070	Resistor: fixed, deposited carbon, 103,500 ohms ±1%, 1 W	
R58	2100-0244	Resistor: variable, wirewound, 100,000 ohms ±1%, 8 W	
R59		Same as R13 Optimum value selected at factory. Average value shown.	
R60		Same as R49	
R61		This circuit reference not assigned	
R62	0816-0002	Resistor: fixed, wirewound, 3000 ohms ±10%, 10 W	
R63	2100-0073	Resistor: variable, composition, linear taper, 125,000 ohms ±20%, 1/4 W	
R64	0815-0001	Resistor: fixed, wirewound, 30,000 ohms ±5%, 10 W	
R65	2100-0153	Resistor: variable, composition, linear taper 2000 ohms ±20%, 1/3 W	
R66	0690-3931	Resistor: fixed, composition, 39,000 ohms ±10%, 1 W	
R67		Same as R43	
R68		Same as R66	
R69, 70	0690-2741	Resistor: fixed, composition, 270,000 ohms ±10%, 1 W	
R71	0690-5641	Resistor: fixed, composition, 560,000 ohms ±10%, 1 W	
R72, 73		Same as R13	
R74	0690-1051	Resistor: fixed, composition, 1 megohm ±10%, 1 W	
R75	0690-2251	Resistor: fixed, composition, 2.2 megohms ±10%, 1 W	

See introduction to this section

Table 5-1. Index by Reference Designator (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
R76, 77	0693-2731	Resistor: fixed, composition, 27, 000 ohms ±10%, 2 W	
R78	0690-1841	Resistor: fixed, composition, 180, 000 ohms ±10%, 1 W	
R79	0690-2241	Resistor: fixed, composition, 220, 000 ohms ±10%, 1 W	
R80		Same as R74	
R81		Same as R75	
R82		This circuit reference not assigned	
R83		This circuit reference not assigned	
R84a-f R85a-f	202A-26C	Resistor: fixed, wirewound	
R86 thru R90		These circuit references not assigned	
R91	0816-0005	Resistor: fixed, wirewound, 2500 ohms ±10%, 10 W	
R92		Same as R62	
R93	2100-0258	Resistor: variable, composition, dual tandem, linear taper, 1 megohm/sect. ±20%	
R94		Same as R53	
R95	0727-0199	Resistor: fixed, deposited carbon, 67, 500 ohms ±1%, 1/2 W	
R96, 97		Same as R6	
R98, 99	0730-0036	Resistor: fixed, deposited carbon, 15, 800 ohms ±1%, 1 W	
R100, 101 102		These circuit references not assigned	
R103	0690-1821	Resistor: fixed, composition, 1800 ohms ±10%, 1 W	
R104, 105	0811-0038	Resistor: fixed, wirewound, 145, 500 ohms, ±1%, 3 W	
R106		This circuit reference not assigned	
R107		This circuit reference not assigned	
R108		This circuit reference not assigned	

See introduction to this section

Table 5-1. Index by Reference Designator (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
R109		Same as R65	
R110	0727-0096	Resistor: fixed, deposited carbon, 920 ohms ±1%, 1/2 W	
R111	0727-0165	Resistor: fixed, deposited carbon, 13,200 ohms ±1%, 1/2 W	
R112	0727-0187	Resistor: fixed, deposited carbon, 37,400 ohms ±1%, 1/2 W	
R113	0727-0201	Resistor: fixed, deposited carbon, 71,560 ohms ±1%, 1/2 W	
R114	0727-0213	Resistor: fixed, deposited carbon, 115,000 ohms ±1%, 1/2 W	
R115		This circuit reference not assigned	
R116	0727-0222	Resistor: fixed, deposited carbon, 214,000 ohms ±1%, 1/2 W	
R117	0687-4751	Resistor: fixed, composition, 4.7 megohms ±10%, 1/2 W	
R118	2100-0015	Resistor: variable, composition, linear taper, 500,000 ohms, ±20%, 1/4 W	
R119	2100-0054	Resistor: variable, wirewound, linear taper 500 ohms, ±10%, 2 W	
R120 thru R123		Same as R42	
R124	0816-0032	Resistor: fixed, wirewound, 50 ohms ±10%, 10 W	
R125* R126*		Factory selected part, may be omitted.	
S1	3101-0001	Switch, toggle: SPST	
S2	202A-19C	Range Switch Assy: (includes C15 thru C18, C33, R24A thru R28A, R29)	
S3	202A-19B	Function Switch Assy: (includes C34, R94, R95, R117)	
T1	9100-0026	Transformer, power	
T2, 3	9130-0002	Transformer, pulse	
T4	202A-60B	Transformer, pulse	
V1, 2	1923-0021	Tube, electron: 6AU6	

See introduction to this section

Table 5-1. Index by Reference Designator (Cont'd)

Circuit Reference	® Stock No.	Description	Note
V3	202A-95B	Tube, electron: 6AL5	
V4	1921-0005	Tube, electron: 6C4	
V5	1940-0004	Tube, electron: OA2	
V6	1940-0006	Tube, electron: OA3	
V7, 8	202A-95B	Same as V3	
V9 thru V14		These circuit references not assigned	
V15, 16	1932-0030	Tube, electron: 12AX7	
V17, 18	1932-0029	Tube, electron: 12AU7	
V19		Same as V15	
V20		Same as V17	
V21	1930-0008	Tube, electron: 5UGA/B	
V22, 23	1923-0023 1923-0020	Tube, electron: 6AV5GA or 6AU5GT	
V24		Same as V1	
V25		Same as V5	
		MISCELLANEOUS	
	5060-0632	Binding Post Assembly: red	
	5060-0633	Binding Post Assembly: black	
	0340-0086	Binding Post Insulator: (2 holes)	
	0340-0087	Binding Post Insulator: (3 holes)	
	5060-0626	Connector Assembly: (binding post, with ground link)	
	5080-0205	Coupler, flexible: 1/4" to 1/4" shaft	
	417A-32	Coupler, metal bellows type	
	202A-40A	Dial, frequency	
	5040-0609	Escutcheon, dial window	
	1400-0084	Fuseholder	
	202A-901	Operating and Service Manual	

See introduction to this section

Table 5-1. Index by Reference Designator (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
	202A-40B	Indicator, dial	
	0370-0032	Knob: AMPLITUDE	
	0370-0038	Knob: FREQ.	
	0370-0035	Knob: FUNCTION, RANGE	
	6960-0003	Plug button (R65)	
	1450-0020	Pilot Light Assembly: jewel	
	1450-0022	Pilot Light Assembly: lampholder	
	1200-0008	Socket, tube, 9 pin	
	1200-0009	Socket, tube, 7 pin	
	1200-0020	Socket, tube, octal	

See introduction to this section

Table 5-2. Replaceable Parts

ⓗⓟ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS
202A-19B	Function Switch Assy: (includes C34, R94, R95, R117)	28480	202A-19B	1	1
202A-19C	Range Switch Assy: (includes C15 thru C18, C33, R24A thru R28A, R29)	28480	202A-19C	1	1
202A-26C	Resistor: fixed, wirewound	28480	202A-26C	2	1
202A-40A	Dial, frequency	28480	202A-40A	1	0
202A-40B	Indicator, dial	28480	202A-40B	1	0
202A-60B	Transformer, pulse	28480	202A-60B	1	1
202A-95B	Tube, electron: 6AL5	28480	202A-95B	3	3
417A-32	Coupler, metal bellows type	28480	417A-32	1	1
0130-0001	Capacitor: variable, ceramic, 7-45 pf 500 vdcw. Optimum value selected at factory. Average value shown.	72982	503-003	1	1
0140-0006	Capacitor: fixed, mica, 82 pf ±10%, 500 vdcw	00853	RCM15E820K	1	1
0140-0010	Capacitor: fixed, mica, 820 pf ±10%, 500 vdcw	04062	RCM20E821K	1	1
0140-0018	Capacitor: fixed, silver mica, .001 μf ±5%, 500 vdcw	00853	RCM20E102J	1	1
0140-0021	Capacitor: fixed, mica, 39 pf ±10%, 500 vdcw	00853	RCM15E390K	1	1
0140-0026	Capacitor: fixed, mica, 22 pf ±10%, 500 vdcw	00853	RCM15E220K	2	1
0140-0027	Capacitor: fixed, mica, 470 pf ±10%, 500 vdcw	00853	RCM20E471K	3	1
0150-0007	Capacitor: fixed, ceramic, 100 pf ±5%, 500 vdcw	96095	C1-3	1	1
0150-0012	Capacitor: fixed, ceramic, .01 μf, tol. ±20%, 1000 vdcw	56289	29C214A3	3	1
0150-0014	Capacitor: fixed, ceramic, .005 μf, 500 vdcw	96095	D1-4	1	1
0160-0013	Capacitor: fixed, paper, 0.1 μf ±10%, 400 vdcw	56289	160P10494	5	2
0160-0016	Capacitor: fixed, paper, 1 μf ±20%, 400 vdcw	00656	P82ZK18	2	1
0160-0018	Capacitor: fixed, paper, .22 μf ±10%, 400 vdcw	56289	160P22494	1	1
0160-0077	Capacitor: fixed, paper, 4 μf ±10%, 600 vdcw	00853	4106-4	1	1
0170-0001	Capacitor: fixed, polystyrene, .1 μf ±5%, 400 vdcw	14655	obd #	1	1
0170-0023	Capacitor: fixed, polystyrene, .01 μf ±5%, 600 vdcw	74861	6TYV01	1	1
0170-0059	Capacitor: fixed, 1 μf ±5%, 400 vdcw	74861	11318BY	1	1
0180-0011	Capacitor: fixed, electrolytic, 20 μf, 450 vdcw	56289	D32550	2	1
0180-0012	Capacitor: fixed, electrolytic, 20 μf/ sect., 450 vdcw	56289	D32440	1	1
0340-0086	Binding Post Insulator: (2 holes)	28480	0340-0086	1	0
0340-0087	Binding Post Insulator: (3 holes)	28480	0340-0087	1	0
0370-0032	Knob: Amplitude	28480	0370-0032	1	0
0370-0035	Knob: Function, range	28480	0370-0035	2	0
0370-0038	Knob: Freq.	28480	0370-0038	2	0

See introduction to this section

Table 5-2. Replaceable Parts (Cont'd)

ⓗⓟ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS
0687-1011	Resistor: fixed, composition, 100 ohms ±10%, 1/2W	01121	EB1011	4	1
0687-1231	Resistor: fixed, composition, 12,000 ohms ±10%, 1/2W. Optimum value selected at factory. Average value shown.	01121	EB1231	1	1
0687-4751	Resistor: fixed, composition, 4.7 megohms ±10%, 1/2W	01121	EB4751	1	1
0690-1051	Resistor: fixed, composition, 1 megohm ±10%, 1 W	01121	GB1051	2	1
0690-1221	Resistor: fixed, composition, 1200 ohms ±10%, 1 W	01121	GB1221	3	1
0690-1231	Resistor: fixed, composition, 12,000 ohms ±10%, 1 W	01121	GB1231	2	1
0690-1551	Resistor: fixed, composition, 1.5 megohm ±10%, 1 W	01121	GB1551	2	1
0690-1821	Resistor: fixed, composition, 1800 ohms ±10%, 1 W	01121	GB1821	1	1
0690-1841	Resistor: fixed, composition, 180,000 ohms ±10%, 1 W	01121	GB1841	1	1
0690-2231	Resistor: fixed, composition, 22,000 ohms ±10%, 1 W	01121	GB2231	2	1
0690-2241	Resistor: fixed, composition, 220,000 ohms ±10%, 1 W	01121	GB2241	1	1
0690-2251	Resistor: fixed, composition, 2.2 megohms ±10%, 1 W	01121	GB2251	2	1
0690-2731	Resistor: fixed, composition, 27,000 ohms ±10%, 1 W	01121	GB2731	3	1
0690-2741	Resistor: fixed, composition, 270,000 ohms ±10%, 1 W	01121	GB2741	2	1
0690-3341	Resistor: fixed, composition, 330,000 ohms ±10%, 1 W	01121	GB3341	5	2
0690-3351	Resistor: fixed, composition, 3.3 megohms ±10%, 1 W	01121	GB3351	1	1
0690-3931	Resistor: fixed, composition, 29,000 ohms ±10%, 1 W	01121	GB3931	2	1
0690-3941	Resistor: fixed, composition, 390,000 ohms ±10%, 1 W	01121	GB3941	3	1
0690-5641	Resistor: fixed, composition, 560,000 ohms ±10%, 1 W	01121	GB5641	1	1
0727-0096	Resistor: fixed, deposited carbon, 920 ohms ±1%, 2 W	19701	DC1/2C	1	1
0727-0165	Resistor: fixed, deposited carbon, 13,200 ohms ±1%, 1/2W	19701	DC1/2C	1	1
0727-0187	Resistor: fixed, deposited carbon, 37,400 ohms ±1%, 1/2W	19701	DC1/2C	1	1
0727-0199	Resistor: fixed, deposited carbon, 67,500 ohms ±1%, 1/2W	19701	CF1/2	1	1
0727-0201	Resistor: fixed, deposited carbon, 71,560 ohms ±1%, 1/2W	19701	DC1/2C	1	1
0727-0213	Resistor: fixed, deposited carbon, 115,000 ohms ±1%, 1/2W	19701	DC1/2C	1	1
0727-0222	Resistor: fixed, deposited carbon, 214,000 ohms ±1%, 1/2W	19701	DC1/2C	1	1

See introduction to this section

Table 5-2. Replaceable Parts (Cont'd)

hp Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS
0730-0031	Resistor: fixed, deposited carbon, 10.31K ±1%, 1 W	19701	DC1	1	1
0730-0034	Resistor: fixed, deposited carbon, 14,400 ohms ±1%, 1 W	19701	DC1	1	1
0730-0036	Resistor: fixed, deposited carbon, 15,800 ohms ±1%, 1 W	19701	DC1	1	1
0730-0044	Resistor: fixed, deposited carbon, 27,500 ohms ±1%, 1 W	19701	DC1	1	1
0730-0048	Resistor: fixed, deposited carbon, 33,000 ohms ±1%, 1 W	19701	DC1	2	1
0730-0049	Resistor: fixed, deposited carbon, 37,000 ohms ±1%, 1 W	19701	DC1	1	1
0730-0070	Resistor: fixed, deposited carbon, 103,500 ohms ±1%, 1 W	19701	DC1	1	1
0730-0077	Resistor: fixed, deposited carbon, 181,000 ohms ±1%, 1 W	19701	DC1	1	1
0730-0083	Resistor: fixed, deposited carbon, 284,000 ohms ±1%, 1 W	19701	DC1	1	1
0730-0088	Resistor: fixed, deposited carbon, 405,000 ohms ±1%, 1 W	19701	DC1	4	1
0730-0100	Resistor: fixed, deposited carbon, 800,000 ohms ±1%. Optimum value selected at factory. Average value shown.	19701	DC1	1	1
0730-0103	Resistor: fixed, deposited carbon, 900,000 ohms ±1%. Optimum value selected at factory. Average value shown.	19701	DC1	4	1
0730-0106	Resistor: fixed, deposited carbon, 1.031 megohm ±1%, 1 W	19701	DC1	2	1
0730-0113	Resistor: fixed, deposited carbon, 2.163 megohms ±1%, 1 W	19701	DC1	2	1
0730-0126	Resistor: fixed, deposited carbon, 5.16 megohms ±1%, 1 W	19701	DC1	1	1
0811-0038	Resistor: fixed, wirewound, 14,500 ohms ±1%, 3 W	91637	RS2	2	1
0813-0031	Resistor: fixed, wirewound, 42,000 ohms ±10%, 5 W	91637	CS5	2	1
0813-0032	Resistor: fixed, wirewound, 50,000 ohms ±10%, 10 W	91637	CS5	1	1
0813-0033	Resistor: fixed, silicon, 60,000 ohms ±10%, 5 W	91637	CS5	4	1
0815-0001	Resistor: fixed, wirewound, 30,000 ohms ±5%, 10 W	35434	C10	1	1
0816-0002	Resistor: fixed, wirewound, 3000 ohms ±10%, 10 W	35434	C10	2	1
0816-0005	Resistor: fixed, wirewound, 2500 ohms ±10%, 10 W	35434	C10	1	1
1200-0008	Socket, tube, 9 pin	71785	121-25-11-055	6	1
1200-0009	Socket, tube, 7 pin	91662	316PH-3702	9	1
1200-0020	Socket, tube, octal	71785	101-12-10-044	4	1
1400-0084	Fuseholder	36555	342014	1	1
1450-0020	Pilot Light Assembly: jewel	72765	14L-15	1	0

See introduction to this section

Table 5-2. Replaceable Parts (Cont'd)

ⓗⓟ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS
1450-0022	Pilot Light Assembly: lampholder	72765	2020-AE	1	0
1901-0033	Diode, silicon	07910	1N485B	12	12
1901-0016	Diode	94991	D2361	1	1
1921-0005	Tube, electron: 6C4	24446	6C4	1	1
1923-0020	Tube, electron: 6AU5GT	24446	6AU5GT	2	2
1923-0021	Tube, electron: 6AU6	24446	6AU6	3	3
1923-0023	Tube, electron: 6AV5AG	24446	6AU5GA	2	2
1930-0008	Tube, electron: 5U4GA/B	86684	5U4GA/B	1	1
1932-0029	Tube, electron: 12AU7	12859	12AU7	3	3
1932-0030	Tube, electron: 12AX7	86684	12AX7	3	3
1940-0004	Tube, electron: OA2	86684	OA2	2	2
1940-0006	Tube, electron: OA3	86684	OA3	1	1
2100-0006	Resistor: variable, wirewound,linear taper, 5000 ohms ±10%, 2 W	71590	21-010-357	4	1
2100-0009	Resistor: variable, composition, linear taper, 25,000 ohms ±20%, 1/3W	71450	Type 45	1	1
2100-0015	Resistor: variable, composition, linear taper, 500,000 ohms ±20%, 1/4W	71590	Model 2	1	1
2100-0054	Resistor: variable, wirewound, linear taper, 500 ohms ±10%, 2 W	71450	Type 252	1	1
2100-0073	Resistor: variable, composition, linear taper, 125,000 ohms ±20%, 1/4 W	71450	Type 45	1	1
2100-0153	Resistor: variable, composition, linear taper, 2000 ohms ±20%, 1/3 W	71450	Type 45	2	1
2100-0244	Resistor: variable, wirewound, 100,000 ohms ±1%, 8 W	28480	2100-0244	1	1
2100-0258	Resistor: variable, composition, dual tandem, linear taper, 1 megohm/sect. ±20%	71450	2-45	1	1
2100-0435	Resistor: variable, composition, linear taper, 1 megohm ±30%, 1/4 W	71450	Type 45	6	2
2110-0003	Fuse, cartridge: 3 amp (115 V)	36555	312003	1	10
2110-0005	Fuse, cartridge: 1.6 amp (230 V)	71400	MDL 1.6	1	0
2140-0012	Lamp, incandescent: 6-8V, 2 pin base GE #12	24446	GE-#12	1	1
3101-0001	Switch, toggle: SPST	04009	80994-H	1	1
5040-0609	Escutcheon, dial window	28480	5040-0609	1	0
5060-0626	Connector Assembly: (binding post with ground link)	28480	5060-0626	1	1
5060-0632	Binding Post Assembly: red	28480	5060-0632	3	1
5060-0633	Binding Post Assembly: black	28480	5060-0633	1	1
5080-0205	Coupler, flexible: 1/4" to 1/4" shaft	28480	5088-0205	2	1
6960-0003	Plug button (R65)	90763	6960-0003	1	0
8120-0015	Power Cable	70903	KH3981	1	1
9100-0026	Transformer, power	28480	4460	1	1
9110-0004	Inductor: 6H at 125 Ma, 264 ohms	28480	1002	1	1
9130-0002	Transformer, pulse	28480	3002	1	1

See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire & Cable Company	Redwood City, Calif.
04870	P. M. Motor Co.	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronics, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronics, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71528	Standard-Thomson Corp., Clifford Mfg. Co. Div.	Waltham, Mass.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Products Co.	Chicago, Ill.

From: F.S.C. Handbook Supplements
H4-1 Dated: April 1962
H4-2 Dated: March 1962

00015-25
Revised: 25 May 1962

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers,'Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91921	Minneapolis-Honeywell Regulator Co., Micro-Switch Division	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

CODE NO.	MANUFACTURER	ADDRESS
0000F	Malco Tool and Die	Los Angeles, Calif.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CC	Computer Diode Corp.	Lodi, N.J.
000EE	A. Williams Manufacturing Co.	San Jose, Calif.
000FF	Carmichael Corrugated Specialties	Richmond, Calif.
000GG	Goshen Die Cutting Service	Goshen, Ind.
000HH	Rubbercraft Corp.	Torrance, Calif.
000II	Birtcher Corporation, Industrial Division	Monterey Park, Calif.
000KK	Amatom	New Rochelle, N.Y.
000LL	Avery Label	Monrovia, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
000PP	Atohm Electronics,	Sun Valley, Calif.
000QQ	Cooltron	Oakland, Calif.

00015-25
Revised: 25 May 1962

From: F.S.C. Handbook Supplements
H4-1 Dated: April 1962
H4-2 Dated: March 1962

WARRANTY

All our products are warranted against defects in material and workmanship for one year from the date of shipment. Our obligation is limited to repairing or replacing products (except tubes) which prove to be defective during the warranty period. We are not liable for consequential damages.

For assistance of any kind, including help with instruments under warranty, contact your hp field office for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, *except transportation charges.* Estimates of charges for non-warranty or other service work will always be supplied, if requested, before work begins.

CLAIM FOR DAMAGE IN SHIPMENT

Your instrument should be inspected and tested as soon as it is received. The instrument is insured for safe delivery. If the instrument is damaged in any way or fails to operate properly, file a claim with the carrier or, if insured separately, with the insurance company.

SHIPPING

On receipt of shipping instructions, forward the instrument prepaid to the destination indicated. You may use the original shipping carton or any strong container. Wrap the instrument in heavy paper or a plastic bag and surround it with three or four inches of shock-absorbing material to cushion it firmly and prevent movement inside the container.

GENERAL

Your hp field office is ready to assist you in any situation, and you are always welcome to get directly in touch with Hewlett-Packard service departments:

CUSTOMER SERVICE

Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California, U.S.A.
Telephone: (415) 326-3950
TWX No. PAL AL 117-U
Cable: "HEWPACK"

OR (In Western Europe)

Hewlett-Packard S.A.
54-54bis Route Des Acacias
Geneva, Switzerland
Telephone: (022) 42.81.50
Cable: "HEWPACKSA"